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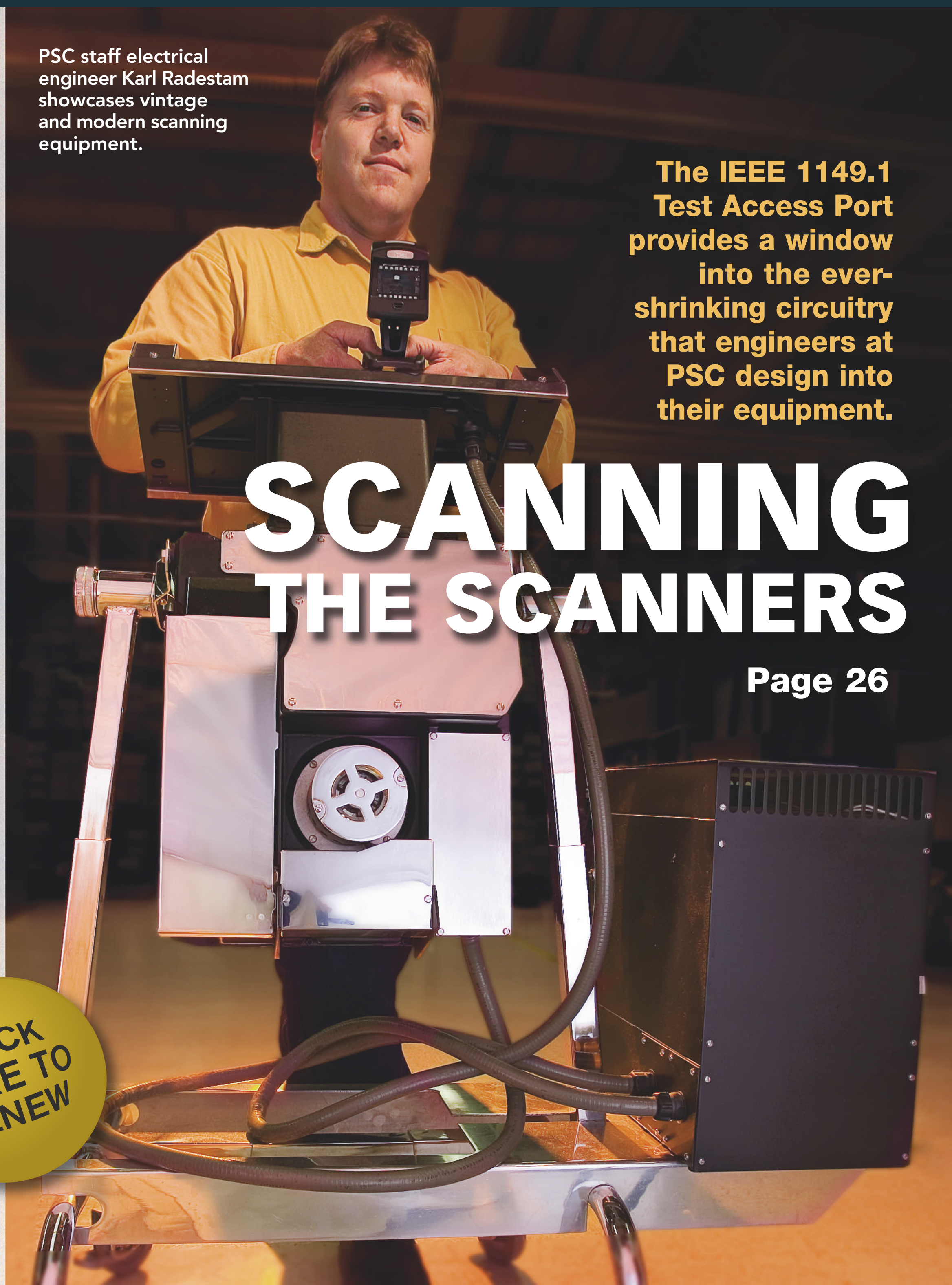

PSC staff electrical engineer Karl Radestam showcases vintage and modern scanning equipment.

The IEEE 1149.1 Test Access Port provides a window into the ever-shrinking circuitry that engineers at PSC design into their equipment.

SCANNING THE SCANNERS

Page 26

Performance on the move

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** Agilent U1251A and U1252A Handheld Digital Multimeter User's and Service Guide, U1251-90002, August 2006*
***Fluke 1897 & 189 Users Manual August 2000, Rev. 2, 6/02*

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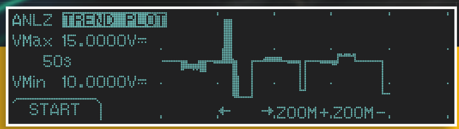
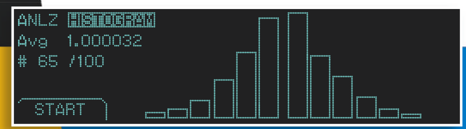


Use the built-in TrendPlot paperless chart recorder to graphically identify the extent of drift and intermittent events in analog circuits.



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COVER BY: RICK RAPPAPORT

NOVEMBER 2006
VOL. 26 NO. 10

Test & MEASUREMENT WORLD®

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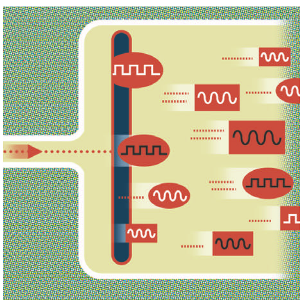

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FEATURES

DEPARTMENTS

TECH TRENDS

TEST DIGEST

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> **Check out these exclusive features on the *Test & Measurement World* Web site:**

Accellera issues revised VHDL standard

A new revision to Accellera's VHDL standard integrates the Property Specification Language (PSL), adds intellectual property (IP) protection methods, and offers improvements that increase designer productivity, including the implementation of a hierarchical signal reference to allow test benches to drive and read signals deep in a design.

www.tmworld.com/1106_accellera

Infrared dynamometer sensors measure engine torque

In September, Sensor Developments Inc. (SDI) released the 01251 series of infrared dynamometer torque sensors. While inquiring about this new series, contributing editor Greg Reed quizzed Rick West, electronics design engineer at the company, about the role of sensors in force measurements.

www.tmworld.com/1106_dyno

BLOG COMMENTARIES AND LINKS

US firm maintains manufacturing prowess

Conventional wisdom has it that manufacturing is migrating from the US to Asia and other areas of lower labor costs. In this view, US engineers must excel at creativity, developing the innovative products that will be built elsewhere. Baldor Electric, a Fort Smith, AK, manufacturer of electric motors, generators, and drives, is bucking this trend, having just expanded its US manufacturing capability. Chief Editor Rick Nelson comments.

www.tmworld.com/nelson_1106

Collective intelligence

Following the theory that two heads are better than one, faculty at the MIT Sloane School of Management have started the Center for Collective Intelligence to study how people use computers and communications to work together. The MIT-CCI was officially launched at a press conference on the MIT campus in Cambridge, MA, on October 13. Senior Technical Editor Martin Rowe comments.

www.tmworld.com/rowe_1106

FROM THE ARCHIVES

- **Managing remote test operations**

  This month's cover story comments on how engineers at PSC headquarters in Eugene, OR, use software they developed to keep tabs on their Asian contract manufacturers' test operations. Last November, we described how Plantronics adapted commercial software to perform similar functions. Read "Bringing home the data," November 2005, in our online archive.

  www.tmworld.com/archives

Test & MEASUREMENT WORLD

EDITORIAL STAFF

Chief Editor: Rick Nelson
rnelson@tmworld.com
ATE & EDA, Inspection, Failure Analysis, Wireless Test, Software, Environmental Test

Managing Editor: Deborah M. Sargent
dsargent@tmworld.com

Senior Technical Editor: Martin Rowe
mrowe@tmworld.com
Instruments, Telecom Test, Fiber-Optics, EMC Test, Data-Analysis Software

Assistant Managing Editor: Naomi Eigner Price
neprice@tmworld.com

Contributing Technical Editors:
Jon Titus, jontitus@comcast.net
Bradley J. Thompson, brad@tmworld.com
Steve Scheiber, sscheiber@aol.com
Greg Reed, editor@aatr.net
Richard A. Quinnell, richquinnell@att.net

Publisher: Russell E. Pratt

Senior Art Director: Judy Hunchard
Senior Art Director/Illustrator: Dan Guidera

Director of Creative Services: Norman Graf
Manager/Creative Services: Gloria Middlebrooks
Prepress Manager: Adam Odoardi
Ad Layout Artist: James Lenza

Circulation Manager: LaGina Thomas
303-470-4328; lnthomas@reedbusiness.com
Reprints: Reprint Management Services (RMS), 800-290-5460, ext. 149; tandmw@reprintbuyer.com
List Rental: Julie Cronin, jcronin@dm2lists.com

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HOW TO CONTACT T&MW

EDITORIAL:
225 Wyman St.
Waltham, MA 02451
Phone: 781-734-8423
Fax: 781-734-8070
E-mail: tmw@reedbusiness.com
Web: www.tmworld.com

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Reed Electronics Group

Science in the pub

Contributing editor Amy Laskowski in her blog (www.tmworld.com/blogs) applauds the recent spate of US Nobel Prizes in science, but she notes that although the prizes demonstrate the capabilities of our top-notch research universities, they mean little with respect to the educational experiences of the vast majority of US students at the elementary and high school levels. She commented, "Americans tend to be passionate about 'hot' science issues, such as the stem-cell debate and evolution, but educators need to find a way to translate that interest into their classrooms" in a way that "fosters interest in math and hands-on learning."

RICK NELSON, CHIEF EDITOR

On the other side of the Atlantic, UK educators are contending with a new syllabus called "Twenty First Century Science." Far from fostering hands-on learning, the new syllabus "moves away from test tubes and Bunsen burners, towards an understanding of such topics as global warming," writes *Guardian* (www.guardian.co.uk) columnist Simon Jenkins.

Jenkins believes this is fine and reports on his own unpleasant experiences with a previous curriculum, which "included trigonometry, advanced algebra, and differential calculus, and related them to physics, engineering, statics, and dynamics. I can not remember any of it, nor have I found the slightest use for it."

The passion is for the politics—not the science. That's completely backward.

He sees an upside to de-emphasizing science: "If I were a scientist or mathematician I would plead for my subject to be optional after primary school…I would want no army of sullen recruits telling the world that my subject was 'boring.'"

Others object to the new syllabus, as reported in the UK public-sector news Website www.24dash.com. Sir Richard Sykes, rector of the Imperial College of London and the former chairman of GlaxoSmithKline, said the new syllabus is a move toward "sound-bite science." The British philosopher Baroness Warnock suggested the new curriculum is "more suitable for the pub than the classroom."

I agree with Baroness Warnock. What little interest people do take in science and technology is primarily related to an attempt to win a pub argument, or an election. The passion Laskowski comments on is for the politics—not the science.

That's completely backward. As Sir Richard said, "Science should inform the news agenda, not the other way around. Before we can engage the public in an informed debate we need the scientists to do the science."

The question of how we encourage passion for science for its own sake remains open. More funding for Bunsen burners is probably not the answer. T&MW

Post your comments at www.tmworld.com/blog.

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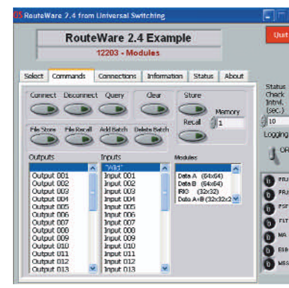

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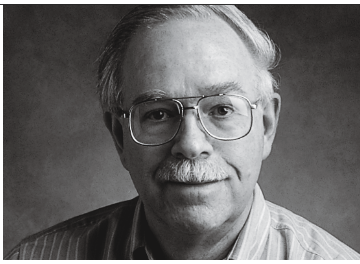
BRAD THOMPSON
CONTRIBUTING TECHNICAL EDITOR
brad@tmworld.com



Into the bay

Regular readers may recall that several years ago I wondered where the under-$1000 spectrum analyzer (SA) was hiding ("Commentary," October 2001). In another column, I discussed a newly announced under-$1000 SA and explored the logistics of purchasing instruments manufactured offshore ("Test Voices," October 2005). Unfortunately, I haven't yet won a lottery, and purchasing a new name-brand SA from a manufacturer exceeds my financial means. After exploring used-instrument and off-lease dealers' offerings—still above my price range—I took a deep breath and double-clicked on the eBay icon. I'll tell you what I've found so far.

First, a search on "spectrum analyzer" returns many listings of dead and working instruments (and pieces thereof), interconnecting cables, and manuals (printed originals and CD-ROM copies). You can narrow the selection by searching for specific models and manufacturers.

Pick an instrument listing and read the description. Look at the pictures that should accompany the listing—are the photos consistent with any obvious physical defects (e.g., a broken handle or dented cover) noted in the description? Check areas around the front-panel controls for heavy wear. Are rear-panel air filters present and clean? While cleanliness may appear cosmetic, at least the seller cared enough to improve an instrument's outer appearance. Look for calibration-sticker dates.

Don't hesitate to ask whether higher-resolution photos are available, and always devise a question to ask the seller. If you get no response, look for another seller. Read "Feedback" ratings with skepticism—eBay's 80-character limit doesn't provide much useful information, but a careful reading of negative ratings and responses reveals how a seller handled past disputes. Be suspicious of sellers with monikers such as "Sleazoid" or "Nastyman" that offer backscratchers and adult videos along with test equipment.

If sharply defined photos show an instrument with power applied, look for front-panel error indicators, blurred CRT displays, and missing rear-panel interconnecting cables. Most auction photos show what's promised in the description, so ask about any discrepancies.

Above all, remember the two laws of auctions: Let the buyers beware, and don't scratch your head during bidding. T&MW

FOR MORE INFORMATION

More notes on my attempts to purchase a spectrum analyzer at auction and what I received will appear in future columns as time and topics permit. Wish me luck!

In my October 2001 column, I asked, "Where's the under-$1k spectrum analyzer?":
www.reed-electronics.com/tmworld/article/CA163505.html

By October 2005, I noted the arrival of a Chinese-made 500-MHz spectrum analyzer priced at $1 per MHz. My column entitled "Logistics nightmares" points out significant logistics issues that make its purchase potentially risky:
www.reed-electronics.com/tmworld/article/CA6262048.html

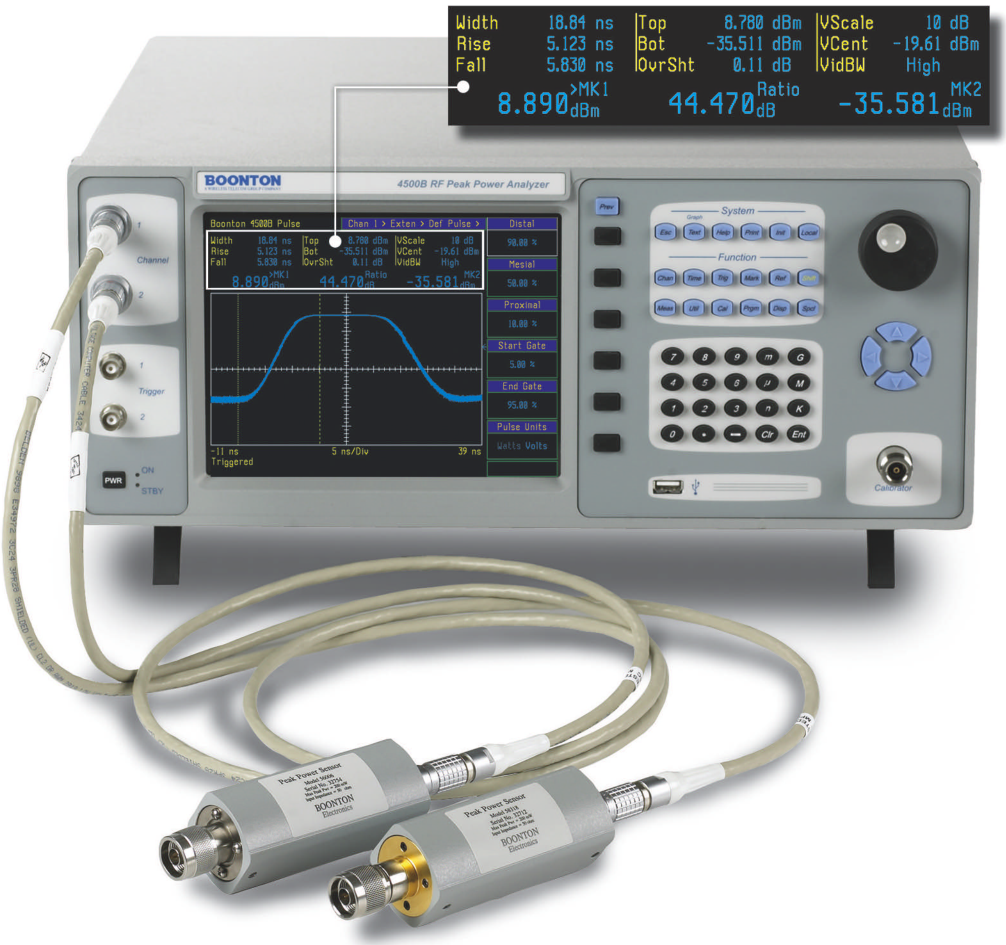
For an explanation of eBay buying and selling tactics, read "99 Tips for Buying and Selling on eBay," by Skip McGrath:
www.skipmcgrath.com/auction_sr/99tips.shtml

Don't overlook eBay itself as a source of information that applies equally well to other purchasing methods. Here's a guide to buying a used oscilloscope:
reviews.ebay.com/Buying-an-Oscilloscope-on-ebay_W0QQugidZ10000000001568756

…and a guide to purchasing a used Tektronix 24xx-series digitizing oscilloscope:
reviews.ebay.com/A-Guide-to-the-Tektronix-2430-amp-40-Digital-Storage-Scopes_W0QQugidZ10000000001714280

Many electronics practitioners also enjoy photography. If you're thinking about purchasing a used medium-format film camera at auction, first review these cautionary comments, many of which apply equally well to test instruments:
photo.net/bboard/q-and-a-fetch-msg?msg_id=004lF1

We've Taken Performance To A New Peak.



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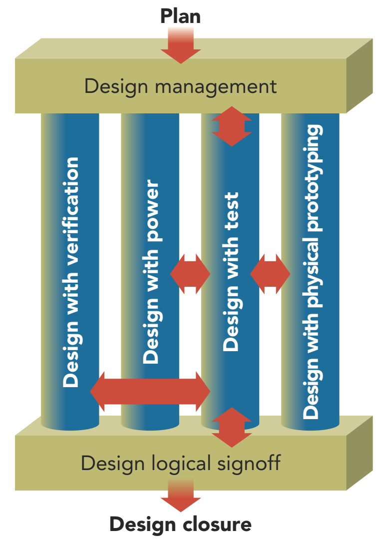
Cadence addresses logic-design predictability crisis

The recently released Cadence Logic Design Team Solution integrates technology from the Cadence Incisive functional-verification and Encounter design platforms to address what Sanjiv Taneja, VP of R&D at the company, calls a "predictability crisis" in logic design.

The predictability crisis, Taneja said, occurs because design-time deltas are now comparable to design times themselves. To address this crisis, the new suite substitutes "design with" in place of "design for" approaches, he said. The "design with" approaches replace serial design stages with four concurrent processes: design with verification, design with power, design with physical prototyping, and design with test. Because these functions occur simultaneously, interdependencies can be addressed without time-consuming iterations.

Taneja elaborated on the suite's design-with-test function, which replaces the traditional tail-end design-for-test process that often exceeds by a factor of three the amount of time scheduled for it. Design-with-test operates in conjunction with the other three pillars of the "design with" suite as well as with design management and design logical signoff functions. He noted as an example that close coupling between design with power and design with test stages not only shorten test-infrastructure-insertion times but also perform two other functions: ensure that power-control functions within a low-power IC work properly, and ensure that scan-test-mode power remains at manageable levels. www.cadence.com.



IEST updates handbook on data-acquisition

The Institute of Environmental Sciences has released the second edition of its *Handbook for Dynamic Data Acquisition and Analysis.* This document contains guidelines for acquiring and analyzing structural (or mechanical) shock and vibration data as well as acoustic and aerodynamic noise data from flight and ground tests for aerospace vehicles.

The primary changes to the second edition are in Section 3 (data acquisition) to reflect improvements in instrumentation. Section 4 (data validation and editing), and Section 5 (data analysis) have also been revised to reflect new procedures. The handbook costs $185 for IEST members and $220 for nonmembers. www.iest.org.

Bennetts transfers DFT services to CloverTest

After 20 years of offering training and consulting services for the chip- and board-test design community, Dr. Ben Bennetts, founder of Bennetts Associates, has transferred his board-level design-for-test (DFT) training and consultancy service to the newly formed CloverTest Associates. CloverTest is made up of the following principals:

- Joe Kadaras, formerly of Asset InterTech and now founder and owner of JEK-Tech, a boundary-scan test accessory and DFT company;
- Ken Posse, formerly of Agilent Technologies and Teseda, who in addition to running his own board-test and DFT consultancy is also chairman of

Editors' CHOICE

Compact system tests CMOS image sensors

Jova Solutions' Image Sensor Lab ISL-1600 Version 2 provides CMOS image-sensor interface, control, test, evaluation, and comparison capabilities in a small-footprint (9x5.5x3.1-in.) test product that offers CMOS image-sensor die manufacturers, module developers, and end-product manufacturers with a way to interface to, control, and test their CMOS image sensors and modules. It also provides product development engineers with software that they can use to exercise and evaluate image sensors and modules.

The vendor positions the ISL-1600 Version 2 as an alternative to three other test approaches: high-end fully automated production-test machines, which entail high costs; low-end evaluation boards from image-sensor manufacturers, which work only with one vendor's chip; and build-it-yourself approaches, which require the purchase, configuration, and programming of multiple instruments. The ISL-1600 2.0 is a generic tool that can test most image-sensor designs, regardless of the die or module manufacturer.

Base price: less than $5000. *Jova Solutions, www.jovasolutions.com.*

the IEEE P1687 (Internal JTAG) working group; and

- Bernard Sutton, formerly of Teradyne and now running his own board-manufacturing and test consultancy.

In addition to offering the "Ben Bennetts" range of board DFT seminars, CloverTest will expand its range of seminars and consulting services by bringing together leading experts from across the globe. www.clovertest.com.

DirectIndustry launches searchable PDF library

DirectIndustry.com announced that it has launched its Virtual Technical Library, which allows visitors to search up to 90,000 pages of technical information from over 3000 PDF files, directly from the company's home page. Before the launch of this service, visitors would have had to search individual exhibitors' catalogs one by one. The company reports that the Virtual Technical Library is attracting more than 12,000 visitors per day.

"Creating the virtual technical library was a logical step after the unexpectedly rapid uptake of our PDF search service launched in late 2005," said Corentin Thiercelin, CEO of the company. www.directindustry.com.

CALENDAR

Wireless and Microwave Technology Conference: WAMICON 2006, December 4–5, Clearwater, FL. Sponsored by IEEE. *www.wamicon.org.*

Measurement Science Conference, January 22–26, Long Beach, CA. Sponsored by The Measurement Science Conference. *www.msc-conf.com.*

APEX/IPC Printed Circuits Expo, February 20–27, Los Angeles, CA. Sponsored by IPC. *www.goapex.org.*

To learn about other conferences, courses, and calls for papers, visit www.tmworld.com/events.

Editors' CHOICE

AWG sets speed record

Tektronix has increased the speed of its arbitrary waveform generator with the AWG7000 series. The models AWG7051 and AWG7052 have one and two channels, respectively, with 5-Gsample/s speeds. A third model, the AWG7101, has one channel at 5 Gsamples/s, and the final model—the AWG7102 with interleaving option—samples at 20 Gsamples/s and has a 5.8-GHz bandwidth. The option lets you interleave the instrument's two 10-Gsample/s channels to double the sample rate on one channel.

All of the instruments feature a 10.4-in. display so you can see a representation of the analog output signal. The display shows the output waveform stored in the instrument's memory. You can capture real-world signals from a Tektronix oscilloscope and replay them on the AWG. You can also simulate serial data streams, adding pre-emphasis and jitter for testing copper and wireless data links.

All models come with 64 Mbytes of waveform memory, but you can use loops and branches to produce longer waveforms. An external trigger lets you start a waveform and a conditional trigger lets the instrument jump to a particular signal pattern stored in memory.

Price range: from $60,000 for the AWG7051 to $120,000 for the AWG7102 with high-speed option. *Tektronix, www.tektronix.com.*

Instruments and software address military needs

> > > Autotestcon, September 18–21, Anaheim, CA. www.autotestcon.com.

Geotest (www.geotestinc.com) introduced a flurry of products during the Autotestcon show: the GX7100 3U/6U PXI smart chassis; the 3U PXI GX5292 module, which incorporates dynamic direction control on a per-pin and per-vector basis; the 3U PXI GX5733, which offers static TTL and configurable digital I/O channels with FIFO memory; and the 3U PXI GX2002 RF power analyzer card (developed in partnership with **ZTEC Instruments**), which performs CW and pulse-power measurements, frequency measurements, and pulse-repetition period measurements on RF signals from 100 MHz to 3 GHz.

Geotest also introduced the GP1616 (a replacement for the obsolete Hewlett-Packard 8116 function generator) and announced the release of ATEasy 6.0, an enhanced test executive that supports touch-screen applications, customization of user and group privileges, and .NET 2.0 components and LabView 8.0/8.20 VIs.

For its part, ZTEC (www.ztecinstruments.com) demonstrated its new ZT4610 family of digital storage oscilloscopes. Available in PCI, CompactPCI, PXI, and VXI formats, the ZT4610 family offers 4-Gsamples/s real-time sampling with an 800-MHz analog bandwidth; an equivalent-time (multi-capture reconstruction) or interpolated-time (single-capture reconstruction) mode can be used to achieve 200-Gsamples/s operation.

Data Translation (www.datx.com) announced an initiative to create an LXI-based software programming standard for synthetic instruments based on its Measure Foundry software. The company demonstrated a system consisting of bench and rack-mount instruments under Measure Foundry control; the software "deconstructed" the instruments and reconfigured them as required for different applications.

PrecisionWave (www.precisionwave.com) demonstrated its p1411A RF vector signal generator, which features a spectrum-analyzer display along with an internal IQ waveform generator. The instrument is available in bench or ATE configurations. Serving the 800-MHz and 1700-MHz cellular bands, the p1411A produces EDGE, GSM, IS-95, NADC, PHS, WCDMA, and CW signals.

BAE Systems (www.baesystems.com), **National Instruments** (www.ni.com), and **Phase Matrix** (www.phasematrix.com) announced that they are collaborating on a 26.5-GHz synthetic instrument based on PXI Express. Phase Matrix's contribution to the effort will be a 26.5-GHz PXI Express downconverter. BAE Systems plans to build the synthetic instrument using the new downconverter, combining it in a National Instruments chassis with NI controllers and IF digitizers.

Agilent Technologies (www.agilent.com) announced that its MXA signal analyzer and MXG signal generator will have options for LXI Class B compliance by the fall of 2007. The MXA and MXG are currently LXI Class C compliant. Other LXI proponents used the **LXI Consortium** (www.lxistandard.org) booth to tout LXI's benefits.

Amrel (www.amrel.com) introduced its SPD dual-channel 300-W to 360-W switch-mode programmable power supply, which fills what the company calls a gap in the 200-W to 600-W range. The company also demonstrated its new ZVL programmable 0–V electronic load, which comes in 100-W and 200-W, 0-VDC to 150-VDC versions.

Dow-Key Microwave (www.dowkey.com) demonstrated its DK-PXI-1001 18-GHz 4x4 nonblocking matrix and its 4104-4/10 DC to 18-GHz bidirectional coaxial RF switch matrix. **Senariotek** (www.senariotek.com), along with **COM DEV** (www.comdev.ca/codeone), demonstrated its e-trak smart RF switch matrixes, which provide for remote inline calibration correction based on COM DEV's CodeOne software. **Virginia Panel** (www.vpc.com) demonstrated its iCon connector modules, which accommodate up to 320 signal contacts and support signal, power, or coaxial connections in homogeneous or hybrid configurations.

Adlink Technology America (www.adlinktech.com), exhibiting in conjunction with the **PXI Systems Alliance** (www.pxisa.org), introduced its PXI 2016 data-acquisition card, which provides 12-bit, 1-Msample/s performance. The company also introduced its 14-slot compact PXIS-2670 chassis; a separate power partition accommodates 500-W power supplies by effectively dissipating heat and controlling radiated emissions. T&MW

Exhibiting in conjunction with the PXI System Alliance, Adlink introduced its PXI 2016 data-acquisition card, which provides 12-bit, 1-Msample/s performance.

Courtesy of Adlink.

MARTIN ROWE
SENIOR TECHNICAL EDITOR
m.rowe@tmworld.com

Across the digital divide

Serial buses run through ICs, connectors, cables, and backplanes at speeds of 10 Gbps. Digital engineers must characterize these devices for impedance, crosstalk, reflections, and return loss. For many engineers, the transition into the analog RF world started by crossing a language barrier.

Mike Resso of Agilent Technologies made the transition, but needed help from microwave engineers. "In school, you decide if you're going to be a digital or analog engineer," said Resso, "I studied digital and, until recently, didn't need to deal with analog. The microwave engineers helped me understand it, but only after we bridged a language gap." What Resso called "crosstalk," they called "isolation." He had to learn to use a vector-network analyzer (VNA) because his time-domain reflectometer (TDR) lacked the bandwidth and dynamic range he needed.

Microwave engineers have to cross the chasm the other way. They often use two-port analyzers for single-ended devices. Now, they have to use four ports to characterize the differential pairs in a serial bus.

To characterize a differential-pair signal path, a VNA must excite one port side at a time and calculate the pair's impedance, loss, reflections, and crosstalk. "VNAs don't have differential drive," said Tom Brinkoetter, product manager at Anritsu. "You need at least a four-port VNA to characterize one differential pair." VNA manufacturers have responded by offering instruments with as many as 18 ports.

Unfortunately, you have to calibrate your VNA test setup every day. "Calibrating a 16-port setup can take an entire morning," noted Brinkoetter.

VNA manufacturers have also simplified test setup and calibration. VNAs now have tools to streamline setups and calculations. Anritsu, for example, embeds Matlab into its VNAs so you can calculate S-parameters inside the instrument. Rohde & Schwarz uses wizards to help you with calibration and test setup, and the company's VNAs can import component models from popular design tools. "You can adjust the design model right in the instrument," said R&S applications engineer Greg Bonaguide.

VNAs now contain as many as 18 ports for characterizing differential signal paths. Courtesy of Anritsu.

At microwave frequencies, you must compensate for the effects of your test setup when making VNA measurements. You can use the instrument to characterize your test setup, then import the design model and mathematically remove the effects of the test fixture. You can also adjust the design model in the instrument and plot the expected results.

Resso switched to a VNA from a TDR because of the VNA's wider bandwidth and lower noise floor. The bandwidth issue is changing because Tektronix has announced an oscilloscope with a TDR function that covers serial data streams up to 12.5 Gbps (see p. 68). "You don't need a –80-dB to –100-dB noise floor," said product manager James Roth. "Digital designers need noise floors of –10 dB to –40 dB, and a TDR is within that range." T&MW

IEEE publishes electrical safety code

The IEEE has published the 2007 National Electrical Safety Code, which explains how to design, install, operate, and maintain safe electrical installations. It covers batteries, transformers, conductors, circuit breakers, physical clearances, safety warning signs, and protective gear. standards.ieee.org/nesc.

Signal source generates 400-MHz signals

The Model 2940A is a 400-MHz, two-channel, direct digital synthesized signal generator in a benchtop case. The outputs can be set to any value between 200 kHz and 400 MHz with 1-Hz resolution. Standard output level is 0 dBm, with +4 dBm optional. www.novatech-instr.com.

Spectrum analyzer kit handles WiFi

The Wireless Wizard from Bantam Instruments is a complete 2.4-GHz and 5-GHz WiFi measuring kit. It includes a handheld spectrum analyzer, two omnidirectional antennas, and a directional log-periodic antenna. The unit can display all network channels within a WiFi or Public Safety band, and the included datalogging software can be used to download data to a PC. www.bantaminstruments.com.

Background image courtesy of GlobeXplorer

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STEVE SCHEIBER
CONTRIBUTING TECHNICAL EDITOR
sscheiber@aol.com

Outsourcing demands partnership

The most profound change in electronics manufacturing in recent years has been the decline of vertically integrated OEMs who perform all of their own design, production, and test activities. Today, OEMs typically design and market their products and work with one or more contractors who provide manufacturing and test services.

The relationship between OEMs and contractors often proves bumpy. A few years ago, while involved in a project with several contract manufacturers (CMs), I frequently heard the lament that OEMs don't adequately communicate how a product is supposed to work, and they don't cooperate with their contractors on the best way to manufacture and test. As a result, the quality of outsourced products sometimes does not match the quality that could emerge from a more controlled environment.

An AOI system performs pre-reflow inspection on an SMT assembly line. Courtesy of MC Assembly.

Contractors must still address these issues. Bob Tortolano, test engineering manager at Florida-based MC Assembly, put it this way: "OEMs would meet their performance and quality goals better if they truly partnered with their contractors. Even in the best of situations, every day we face the challenge of getting complete information in a timely manner to troubleshoot production or returns effectively."

Tortolano said that OEMs need to recognize the skill differences between them and their contractors. "Companies need to treat their contractors as extensions of their own manufacturing floors. We have the test and assembly expertise that can make or break a new product's success. Success requires involving the contractor up front in initial design, PCB layout, or materials and logistics planning.

"At MC Assembly, we have assembled a new-product introduction team whose sole purpose is to receive new product designs, then create the infrastructure, logistics, process, test, and documentation to support them. Products that are hard to diagnose or don't lend themselves to efficient build and test will always make it more difficult for us to meet our commitments to our customers. Too many times, customers don't allow sufficient ICT access, for example, or they design with obsolete parts."

The ultimate goal of every CM is to deliver high-quality products to customers in sufficient quantities and on time. Manufacturers have long touted the benefits of process feedback, but achieving it requires complete communication among all participating parties. One tool to help in the effort is good manufacturing and test data.

Tortolano explained, "We have adopted a real-time test-data collection system to help us find and correct process and product problems while they are happening." He summed it up this way: "An open and collaborative relationship affords OEMs and their manufacturing partners the best opportunity to optimize the end product." T&MW

Goepel, SPEA team up on ICT

Goepel electronic and SPEA have developed a boundary-scan option, based on Goepel's ScanFlex hardware and Cascon Galaxy software, for the SPEA 3030 in-circuit test (ICT) system. The hardware integrated into the SPEA 3030 includes a ScanFlex PCI controller with a clock frequency of 20 or 50 MHz. A ScanFlex transceiver tailored for integration into ICT features four parallel and independent Test Access Ports. www.goepel.com, www.spea-ate.de.

Flux finds lead-free use

Cobar Solder Products is targeting its 390-RX-HT no-clean wave-soldering flux at lead-free wave-soldering applications. Lance Larrabee, GM, said that the product, developed 15 years ago as a high-temperature flux, provides the wetting performance necessary for today's lead-free applications without breaking down. www.cobar.com.

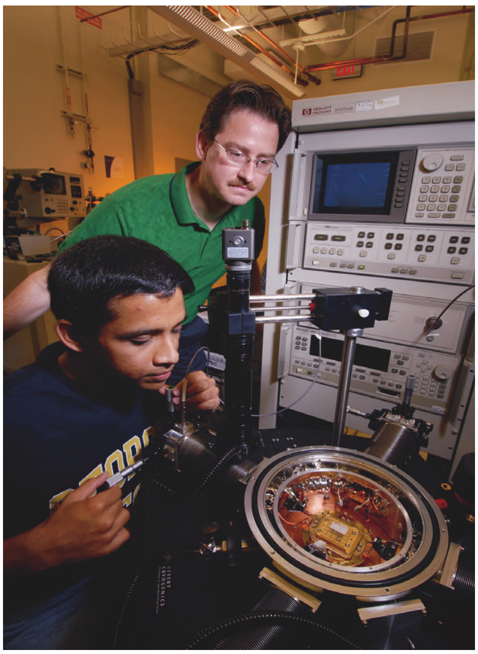
Corelis emulates ARC

Corelis has announced the availability of its USB 2.0-ARC/MetaWare JTAG emulators, which enable the use of a Corelis USB-1149.1/E boundary-scan controller along with MetaWare's debugger for ARC International processors. Integrating the USB-1149.1/E controller from Corelis with the MetaWare debugger permits fast code downloads while enabling MetaWare users to continue using a familiar debugger. Base price: $4945. www.arc.com, www.corelis.com, www.metaware.com.

INSTRUMENTS

How do you measure 500 GHz?

On June 20, 2006, IBM and the Georgia Institute of Technology demonstrated the first silicon-based transistor that could operate at 500 GHz (Ref. 1). To achieve that speed, a team of researchers led by Professor John D. Cressler had to cool the SiGe chip to 4.5 K (–451°F). But how did they know that the transistor could switch at a half terahertz when no test equipment exists that can measure at such a frequency? To find out, I spoke with Cressler by phone.



PhD student Ram Krithivasan (seated) and Professor John Cressler oversee a SiGe chip mounted in a cryogenic test station.

Courtesy of Georgia Institute of Technology.

The researchers used a test setup that lets them measure broadband performance of a device at temperatures down to 4 K using liquid helium. (Ref. 2) "We wanted to push SiGe technology to its limits, not only at room temperature, but across temperature," said Cressler. "It gives you a good understanding of device physics and we can better design and optimize a device for room temperature."

While you can't directly measure speeds to 500 GHz, you can infer how a device will respond at frequencies higher than today's test equipment can measure. To perform the measurement, Cressler and his team measured S-parameters with a vector-network analyzer. They excited the device to 35 GHz and measured its gain. Then, they extrapolated the gain versus frequency to find the device's unity-gain frequency.

"It's a standard technique for measuring high-speed devices," noted Cressler. "We assumed that the gain will roll off at 20 dB/decade. If we can prove that roll off through direct measurements at frequencies that our equipment can cover, then we're highly confident that the extrapolation is correct."

Each measurement point on the device takes several days to make. Researchers must calibrate the system at room temperature using on-wafer calibration structures, then cool the device to 77 K and then to 4.5 K and make each measurement. They make measurements at other temperatures as well. They repeat the calibration and measurement steps at each frequency.

Martin Rowe, Senior Technical Editor

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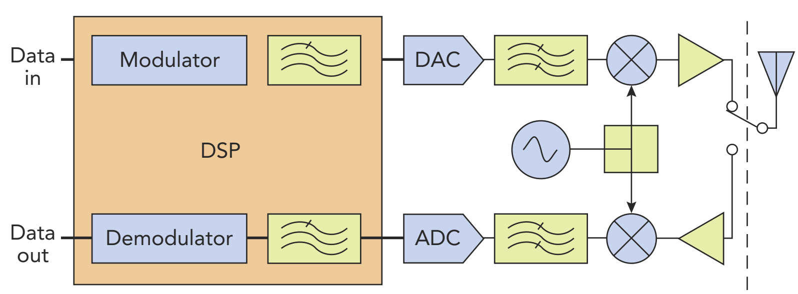
RF TEST

Measuring software-defined radios

Software-defined radios (SDRs) are combining the flexibility of digital signal processing (DSP) with RF circuitry to allow software to dynamically control communications parameters such as carrier frequency, bandwidth, power levels, and data rate. In addition, the software at the heart of these "digital RF" systems can perform functions such as filtering signals, establishing modulation and coding schemes, and determining frequency-hopping patterns. *(continued)*



A digital RF radio employs software running on a DSP to dynamically control communications parameters.

Measuring software-defined radios *(continued)*

The emergence of SDRs is driven by techniques such as the direct upconversion to RF from the output of a digital-to-analog converter (DAC). Such techniques allow more of the analog hardware to be integrated, but they reduce signal access, burying within silicon the test points to which you could once attach your oscilloscope or spectrum analyzer to make traditional measurements such as occupied bandwidth, channel power, adjacent channel power, error vector magnitude (EVM) and correlated power, and rise and fall time.

Furthermore, SDRs require tests beyond these traditional RF transceiver conformance tests and the like to include software-regression testing to ensure that software-controlled operations don't inject unwanted glitches, interference, pulse aberrations, and software-dependent phase errors.

In addition, SDRs often employ nonlinear digitally enhanced power amplifiers that rely on software to perform crest-factor reduction, implement digital predistortion, and provide digital feedback linearization, further complicating measurement tasks.

To provide guidance for SDR troubleshooting, Tektronix has just released an application note that gives tips for applying logic analyzers, oscilloscopes, and real-time spectrum analyzers to the task. The app note provides details on frequency-hopping measurements and the use of a frequency-mask triggering function to identify glitches.

It also describes how to locate crosstalk from microprocessors operating near the 2.4-GHz ISM band, and it provides hints on identifying transients caused by adaptive modulation and coding schemes, such as the scheme employed in HSDPA to switch on-the-fly between QPSK and 16-QAM.

The online version of this article provides a link to the 16-page note, "Software Defined Radio Testing Using Real-Time Spectrum Analysis." www.tmworld.com/2006_11.

Rick Nelson, Chief Editor

DATA SECURITY

Disposal of test data

Your test data—and especially calibration data—will likely outlive the computers that created and initially stored it. When you replace a computer, a hard drive, or other storage device that contains sensitive test data, you don't want that data to be accessed by hackers or competitors. Your company may require "sanitization" or destruction of data-storage devices.

There are many ways to destroy data before disposing of the storage media. For hard drives and flash-memory devices, you can get software that overwrites the media. Hard drives may also require deformation by smashing so that they're totally unusable. Storage media such as CD and DVD discs require outright destruction.

The National Institute of Standards and Technology (NIST) has published guidelines for the sanitization and destruction of data and storage devices. You can download NIST's "Guidelines for Media Sanitization" at csrc.nist.gov/publications/nistpubs.

Martin Rowe, Senior Technical Editor

INSTRUMENTS

Keep the power on

DEVICE UNDER TEST
Uninterruptible power supplies that provide three-phase 480 VAC out from three-phase 480 VAC in. External DC batteries charge during normal operation and provide output power through an inverter should the input drop or fail.

THE CHALLENGE
Monitor the supply's response to various input-voltage conditions including simulated power failures and momentary voltage dips. Measure voltage and current in each phase during the switch to battery power. Compare output voltages to those measured by the supply.

THE TOOLS
- Fluke: handheld DMMs, current clamps. www.fluke.com.
- Soltec: chart recorder. www.solteccorp.com.
- Yokogawa: power analyzer, oscilloscope. www.us.yokogawa.com.

PROJECT DESCRIPTION

Server farms and data centers that constitute the world's data infrastructure must run even in the event of a power failure. Uninterruptible power supplies (UPSs) keep the power coming when utility power fails. Not only must a UPS provide the power needed to keep equipment running, but it must also cut in without any interruption whatsoever; even a short dip in power can cause data loss or equipment failure.

MGE (www.mge-ups.com) produces large UPS systems that provide 60-Hz, three-phase, 480-V power at 300 kVA to 500 kVA at its Costa Mesa, CA, facility. (The company produces 50-Hz systems in France.) The supplies take stored DC energy from a battery and invert it into AC. They switch to battery power should utility power fail.

Because MGE produces these large power supplies in small quantities (10 to 20 each week), the company's technicians perform many tests without automation. To perform a test, a technician measures input and output voltage and current on all phase legs. He or she connects a current clamp to each leg, then connects the clamps to a chart recorder. Six other channels on the chart recorder measure voltage in each leg.

Using a circuit breaker, a technician cuts utility power for 10 s to 30 s while the chart recorder measures voltage and current. A test verifies that the output voltage and current remain within limits with minimal phase shift. A power analyzer monitors the utility power for dips, spikes, and harmonics.

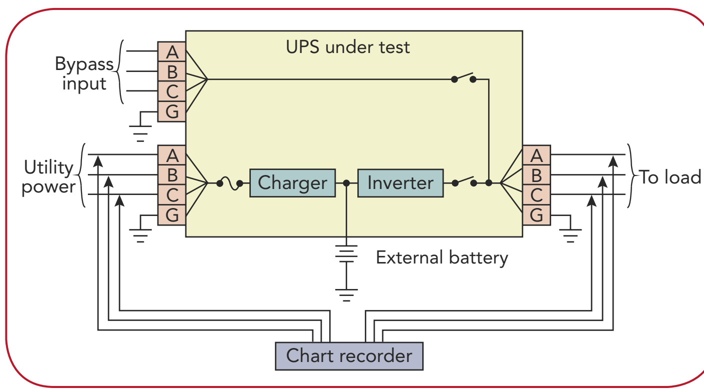
Technicians also test each UPS for overload conditions. Using loads located outside the building, but controlled from the test area, technicians measure voltage and current at 150% of rated load. The battery charger should shut down in an overload condition.

The UPS has a graphical display that lets users, factory technicians, and service technicians monitor its operation. Diagnostic software lets factory technicians calibrate the supply, and it lets both factory and service technicians troubleshoot the supply.

Factory technicians use DMMs to measure leg-to-leg voltages with greater accuracy and resolution than they can get with the chart recorder. They connect laptop computers to the UPS under test through RS-232 ports. Using diagnostic software and a command-line interface, technicians calibrate the UPS by entering correction values.

A UPS also contains setup software that's accessible to field engineers who customize the supply at installation. Settings include cut-in time (1 s to 20 s), which sets the time that it takes the UPS to switch back to utility power once the power is restored.

Technicians also use other test equipment as needed. For example, an oscilloscope lets them view waveforms to troubleshoot a supply.

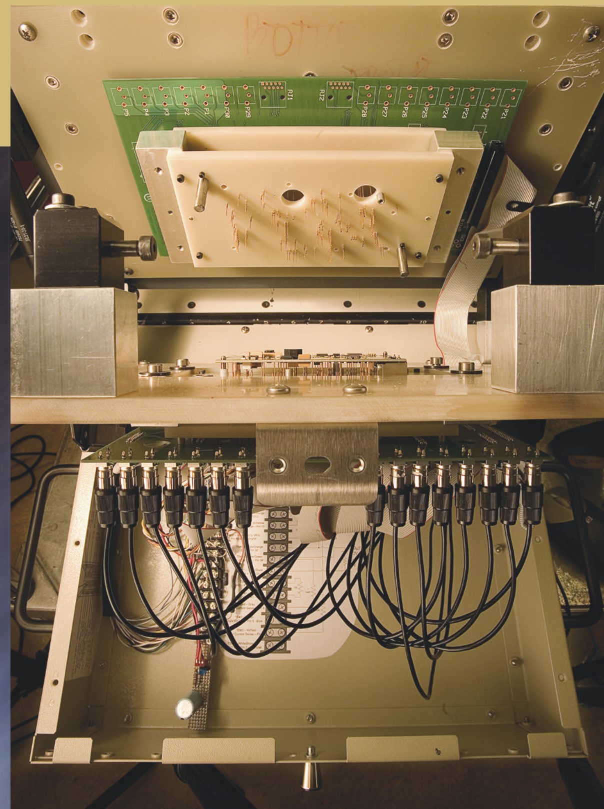


A chart recorder monitors input and output voltage and current during a simulated power failure. The recorder proves that the UPS under test switches to battery power.

LESSONS LEARNED

"Read the fine print," said Michael Loberg, power systems production supervisor. "In using test-and-measurement equipment, it is important to read the entire manual. In one case, a 3000-A-rated current clamp burned during power runs at around 2500 A. The continuous rating of these units was only 2000 A, making for a very expensive repair bill."

Martin Rowe, Senior Technical Editor



RICK RAPPAPORT

Interconnect boards that adapt a test fixture's standard pin-out to the unique needs of a unit under test help to minimize custom wiring.

PSC staff electrical engineer Karl Radestam holds a Magellan scanner, one of the first products for which the company employed boundary-scan technology.

SCANNING

the SCANNERS

THE IEEE 1149.1 TEST ACCESS PORT PROVIDES A WINDOW INTO THE EVER-SHRINKING CIRCUITRY THAT ENGINEERS AT PSC DESIGN INTO THEIR DATA-CAPTURE EQUIPMENT.

RICK NELSON, CHIEF EDITOR

Eugene, OR. Data-capture equipment has evolved significantly since PSC first deployed a laser scanner in 1974 at a Marsh Supermarket in Troy, OH, where the pioneering system read a bar code printed on a "10 Pak" of Wrigley's chewing gum.

Since that debut, PSC has improved the speed and accuracy of its equipment, added weighing capabilities, introduced handheld scanners, and implemented RFID, Bluetooth, and WiFi features to meet the needs of industrial, manufacturing, distribution, transportation, and logistics sectors as well as the retail sector.

To that end, the company complements its Magellan line of point-of-sale (POS) scanners with three other product lines: the QuickScan family of general-purpose on-counter and handheld scanners for low-to-medium volume POS applications, the PowerScan family of handheld bar-code scanners for industrial users needing scanning capabilities from less than 1 in. to more than 36 ft, and the Falcon portable, vehicle, and fixed-station terminals and scanners that collect business-critical data throughout a supply chain.

In addition to adding features like Bluetooth and RFID, the company has steadily improved the speed and accuracy of its laser scanners. "Instead of just having three laser lines, you'll see 12 lines coming out at different angles," said Larry Smith, manager of advanced manufacturing engineering. Such a configuration, he said, enables rapid bar-code reading at any angle—even on hard-to-read labels. "Net throughput for the clerk is what we are looking for." And as the company's hardware has evolved, so, too, has the software, with recent handheld products incorporating Windows CE and Windows Mobile 5.0 operating systems.

Test keeps pace with product advances

As the boards and components inside PSC's products have shrunk, the company's test engineers have developed test techniques that keep pace. Karl Radestam, staff electrical engineer responsible for test in Smith's department, explained that the techniques he developed handle not only test, but also device programming and boot-code installation. The company's test software has evolved as well, with QNX-based test programs giving way to ones written in Visual Basic and the Goepel electronic System Cascon suite.

Radestam is one of 10 engineers in the company's advanced manufacturing engineering department, which ensures that the products designed by PSC's 100 development engineers can be economically built and tested.

A key technology that the company has adopted is boundary scan, which, Radestam said, has become a requirement for ICs that have ball-grid array (BGA) packaging and have direct or indirect boundary-scan-I/O access. "As more ICs move toward BGA and smaller packaging with tighter board designs that allow fewer test points, boundary scan is becoming the industry standard, replacing the older ICT [in-circuit test] methods," Radestam said. In addition, boundary scan offers programming capability for flash and complex programmable logic devices (CPLDs), so device updates can be done with minimal hardware—even in the field. Radestam first employed boundary scan for the company's current line of Falcon handheld products, which employ PSC's densest, most expensive circuit boards, populated with BGAs.

From a test-development standpoint, Radestam said, his efforts begin with consultations with development engineers and extend to pilot low-volume production runs at the PSC headquarters. Finally, he provides support for the test hardware and software provided to PSC's contract manufacturers (CMs) in Asia.

A basic test system that Radestam develops (**Figure 1**) employs boundary-scan and analog I/O boards and CION (Configurable I/O Network) boundary-scan modules from Goepel electronic. In addition to boundary-scan test hardware and software, PSC's test systems employ hardware for supplying power, actuating unit under test (UUT) buttons, and measuring voltage and current signals. The hardware can include relay cards, serial-port cards, parallel-port cards, and USB devices in addition to digital multimeters (DMMs), oscilloscopes, and various sensors for LEDs and speakers. All test fixtures use Visual Basic software for the user front end.

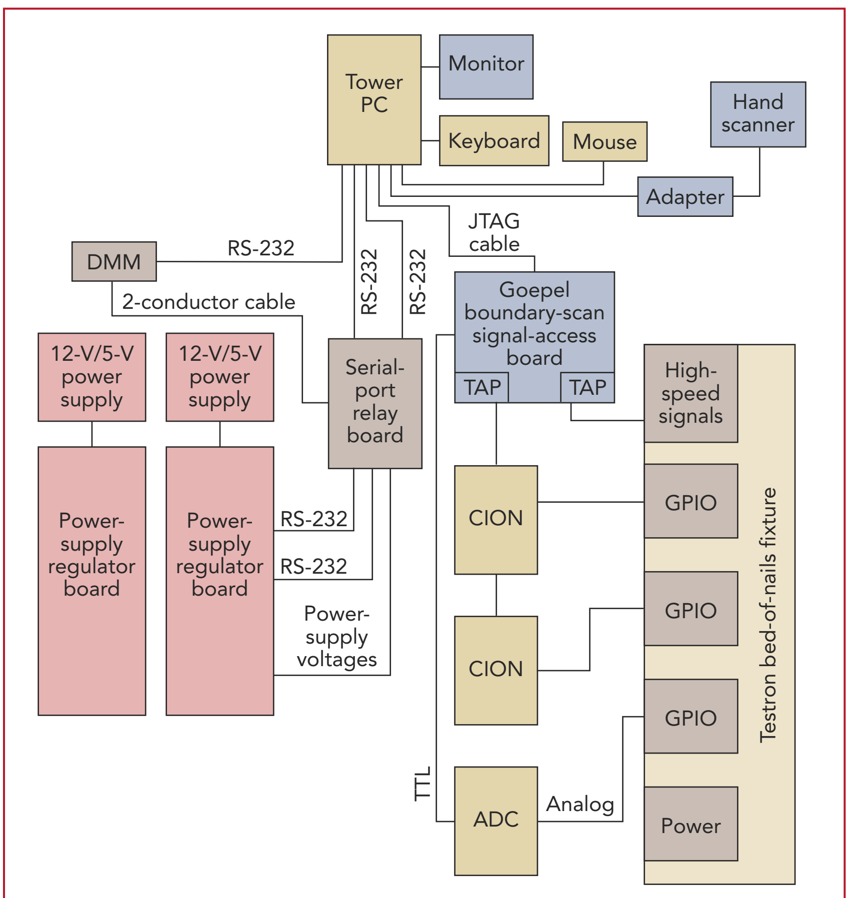


FIGURE 1. This simplified diagram of a PSC test system shows the principle components and subsystems as well as primary signal and data lines. Other components, not shown here, can include actuators and sensors for testing keyboards, touch screens, and displays, and, for products that work with PCMCIA cards, a card-slider mechanism.

Notably, despite the amount of press coverage given to instrument interfaces such as PXI and LXI, PSC is not moving toward adopting them. The company relies primarily on not even GPIB but on RS-232. Said Smith, "We won't buy an instrument that doesn't have an RS-232 interface." He said he grew up around GPIB and worked with some of the authors of the original HPIB spec, and he noted the irony of RS-232 now being the company's instrument interface of choice: "It's hard for me to accept coming back around to RS-232," but he added that it's the simplest and most cost-effective interface for PSC's test applications.

Fixtures become simpler

In the approximately three years that the company has been using boundary scan, PSC's test fixtures themselves have evolved into simpler, lower-cost systems. For a basic system, Radestam said, "The hardware includes a Goepel analog board for measuring different analog voltages and, in addition, separate Goepel CION modules wired into wherever there is a boundary-scannable connectorized point on the Falcon product under test. It also includes some custom circuitry: a switching relay for power and a couple of voltage regulators. We also included a card-slider mechanism because this product worked with a PCMCIA card slot" whose functionality had to be tested.

The original boundary-scan-compatible fixture, said Radestam, wasn't designed to support hardware reuse—it integrated custom test hardware for a single UUT into one box. "We are limited to testing one product on it," he said.

The original fixtures also each include a custom test-interface board and require a lot of hand wiring. In addition, each employs a relatively expensive industrial computer with similarly costly software licensing. The move now, said Smith, is toward configuring test systems with individual standard commercial PCs and their own instrumentation, although the company continues to use its original fixturing to make best use of the software licenses it has purchased.

The way PSC develops its new text-fixture boards has resulted in significant cost and time savings. Smith explained, "We've gone from producing G10 test-

fixture boards that must be individually engineered and hand wired to an approach where we develop and lay out the interconnect boards at the same time we lay out the product board."

The interconnect boards are designed to adapt PSC's standard Testron test-fixture pin-out configuration to the unique needs of the board under test and are laid out to enable custom hand wiring to be replaced by double-sided Pogo pins. Smith noted that the approach shortens considerably the time needed to get a pilot line up and running. "We get the fixture boards back close to the same time we get the UUT—within a few hours. In the past, it took something like two weeks for the custom wiring.

"The interconnect assembly is basically a sandwich that supports the Pogo pins," said Smith. "Any time we have a change in the UUT boards, instead of having to carefully dismantle the fixture and send the interconnect boards to a model shop to have new holes drilled, we just get a new set of PCBs made up and swap them out. A real advantage of this is that when we go offshore, in order to make a change in the CM's test system, it's just a matter of sending them this new [interconnect board] stack. In the past, we'd have to physically build up a system and send it to them, and they would have to turn around and send the old one back, which was very cumbersome."

Regardless of fixture vintage, the test process powers up the UUT, tests its JTAG chain, measures analog voltages, and finally does the complete boundary-scan test where it actually wiggles all the nodes internally. Test programs that Radestam develops determine what tests get performed for each UUT and in what sequence. He designs the user interface that a test technician sees using Visual Basic. The Visual Basic interface also serves as a front end to an SAP SQL database and statistical-processing tool. Radestam said that each test system records results of each subtest to a local hard drive; results are later uploaded to a central server.

Radestam programs the subtests themselves in Goepel's System Cascon software. A typical test sequence might include power-off resistance measurements using a DMM. Subsequent steps include powering up 5-V and 12-V power-supply bricks, measuring power-supply voltage and current, and invoking Cascon to measure analog voltages and perform an internal JTAG-chain test followed by a full JTAG test of all JTAG-compliant circuit nets.

Test development begins at alpha stage

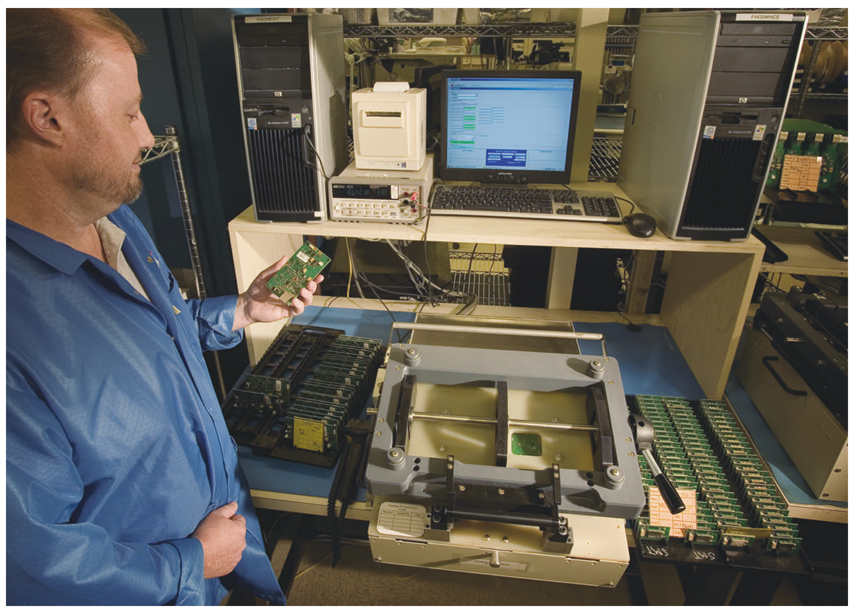
Radestam elaborated on the test-development process, which for him begins when product-development engineers release an alpha electrical schematic. "At that point they don't have the layout done—they just have the electrical schematic developed with a Mentor Graphics schematic-capture tool. I take the netlist and convert it to EDIF [electronic design interchange format], which I can then import into Cascon. I'll also create any other files I might want, such as PDF files," which he likes to produce so he has a text-searchable version of the schematics that he can work with without using a schematic editor.

Radestam then defines the boundary-scan test points he needs and associates them with particular CION modules. At that point, at the alpha stage, he will usually parse the UUT netlist without merging it with the CION netlist, because he won't be building fixture hardware until later. Parsing the unmerged netlist allows him to create a file that allows technicians to load boot code and CPLD configuration code into a prototype UUT using a low-cost programming cable.

He said that, for the second go-around, "When I get to beta I'll take the same project and do a 'save as,'" a special feature that he asked Goepel to develop for Cascon so he could preserve his work at various stages of the test-development process. "Then, I'll go ahead and merge the UUT's and CION modules' netlists to combine the two."

At either the alpha or beta stage, the parsing process tends to generate error messages regarding parts in the UUT's bill of materials that aren't supported within Cascon. Radestam can develop missing models himself from the information on the data sheet, but he said he often saves time by obtaining the models from Goepel, a service he pays for as part of his Cascon support package. "It could be time prohibitive for me" to develop the models, he said, "but Goepel has people who do this all day long."

On having successfully completed the parsing process, Radestam uses Cascon to create scan paths. He then develops executables to perform JTAG and interconnect tests. Sometimes, he will develop RAM tests within Cascon, but he noted that many of PSC's products employ a built-in RAM self-test, making the Cascon tests redundant. *(continued)*



RICK RAPPAPORT

Engineer Chuck Polley examines a test fixture for which he developed the Pogo-pin interface.

Radestam then develops cluster tests for the non-JTAG-compliant components that often surround a boundary-scan-compatible processor and CPLD. Many of these parts can be tested with proper models or custom boundary-scan tests, he said, but some have special requirements for high-speed serial data, control lines, clocking, and register access that make it almost impossible to develop boundary-scan tests for them. For these special ICs, Radestam develops a custom embedded manufacturing test capability that loads with a UUT's boot code or app code to permit a functional test to be done separately after boundary-scan testing.

Next, using the Pascal-like Caslan language in System Cascon, he creates manual procedures for analog measurements, delay tests, and so on. In addition, he uses the Cascon environment to develop executables for loading boot code into flash and for loading serial vector format (SVF) files for configuring CPLDs.

RICK RAPPAPORT

Larry Smith, manager of advanced manufacturing engineering at PSC, says his company's test-system architecture helps PSC engineers keep in touch with its offshore contract manufacturers without having to travel extensively.

Meanwhile, Radestam said, he has passed on his test-point requirements and his connection list for connecting the CION modules to the UUT to engineer Chuck Polley, who develops an electrical schematic of the circuit-board interface, essentially representing those test-point connections. Polley provides his schematic to a circuit-board designer, who matches the test-point connections one-for-one with the UUT circuit board he just designed. And when a product revision comes out, the designer who redesigns the circuit board will revise the test-fixture circuit board as well, often without the need for test-engineering input. "I may have minimal involvement or even not need to be involved at all," said Radestam.

High-speed port augments JTAG

Radestam noted that while boundary scan is adept at loading boot code and CPLD configuration information, it does have its limits. Those limits come into play for UUTs that also require the uploading of separate applications code. App code, said Radestam, can take up as much as 64 Mbytes in products like the Falcon, and he said that the JTAG port is too slow for loading that much code.

Consequently, the company employs an alternate high-speed serial test port for uploading app code. Radestam noted that the test-port approach enables smarter uploads. "You can look at the binary file and see where the empty spaces are and not load those. It's much more efficient and quicker than JTAG." He said that the serial test port can't serve for loading boot code because, for products using Windows CE and Windows Mobile operating systems, the boot code must be in place for the serial test port to work. An alternative, he said, would be to buy memory devices with boot code already programmed, but that's an expensive approach that makes revisions difficult.

The test port can also help in testing non-boundary-scan parts, he said. He cited as an example a touch-screen controller IC that requires a 12-MHz crystal on it: "To talk to it through its SPI interface, you'd have to wiggle awfully fast—much faster than JTAG permits. So in that case, I have a built-in self-test for it that operates through my test port."

JTAG across the board

Radestam explained that although he first employed boundary scan on the Falcon product line, the company has expanded boundary scan's use to the full

product line-up. Said Radestam, "Our offshore manufacturers relied a lot on in-circuit testing when we first met them. Now, they're pretty much switching over totally to the test fixturing that we supply them with. I don't think they use their ICT for any product we send them." He added, though, that they do use optical inspection and x-ray inspection prior to boundary-scan testing.

Smith commented that it's surprising how few trips PSC engineers have to make to assist the CMs. In part, he said, it's because PSC has duplicates of the CMs' equipment at its headquarters, but it's also because of the way PSC has architected its test systems, which allows PSC and CM engineers to stay in touch without having to physically visit each other. Part of that architecture involves a software "kiosk," installed in PSC's procurement department, which, for example, allows Radestam to sit in his office and log onto a tester at a CM's remote location. If a problem exists, Radestam said, "By the time we are ready to go home at 5 o'clock, we can have answers waiting for them as they start their day."

A training program that brings CM engineers to Eugene to learn about how PSC's products work also helps, Smith said. "The CMs tend to be very proficient at manufacturing but are much less knowledgeable about how our products work," which can hinder their ability to respond adequately to unexpected test results. The training program, Smith said, addresses that.

When asked what he hopes to see next, Radestam said PSC purchasers are always trying to save money by buying ICs that aren't boundary-scan compliant. "If test vendors wanted to make boundary scan simpler to use, they could expand their software support of a much wider variety of non-boundary-scan devices (models and options for custom tests) so there is minimal effort setting up new projects." T&MW

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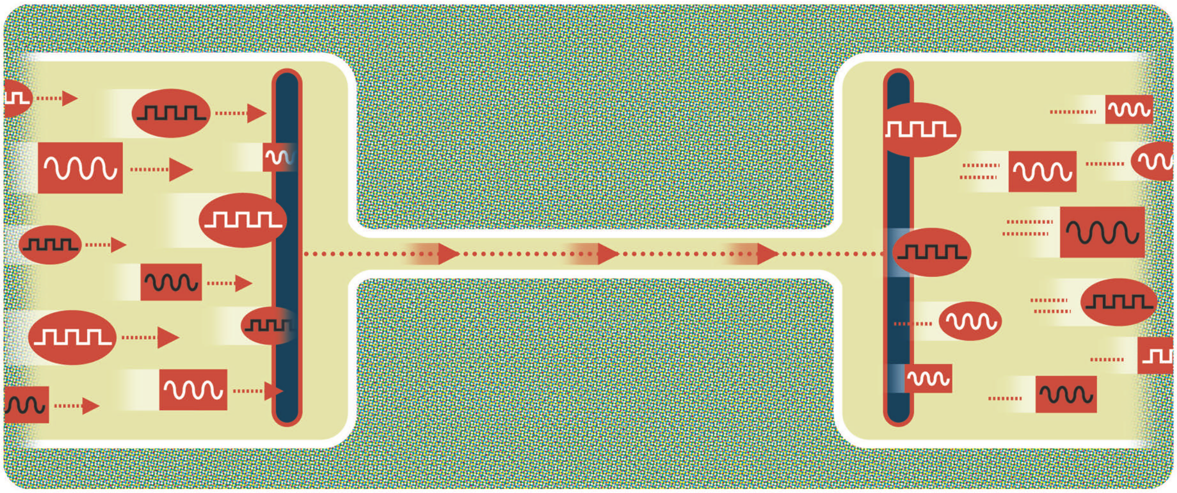


To mux or not to mux?

You may want to rethink your ICT strategy as the tradeoffs associated with the performance, cost, and efficiency of multiplexed in-circuit testers and pure-pin testers evolve.

ALAN ALBEE AND
ANTHONY SUTO,
TERADYNE

In-circuit board-tester pin architectures have traditionally come in two basic configurations. So-called "pure pin" testers dedicate a driver/sensor circuit to every test point on a board. This allows engineers to develop fixtures and test programs in parallel and permits maximum flexibility for last-minute modifications. In "multiplexed" pin testers, a single driver/sensor tests a set of pins—usually eight or 16.

Manufacturers have to weigh the pros and cons of each architecture and choose the best solution for a given situation. Some companies, depending on their product mixes and manufacturing processes, may choose to deploy both types of testers in concert to minimize learning curves, reduce bottlenecks, and keep costs as low as possible.

The pure-pin solution

The earliest in-circuit testers all featured what is now called "pure-pin" design. Every pin that made contact with the board under test had its own driver/sensor combination. Any pin on the tester could be assigned to any node on the board, and (in theory, at least) the tester could drive all pins simultaneously.

Test-program development could proceed in parallel with fixture design and construction. Unless the fixture contained an error, debugging the test program and adding tests did not require any wiring changes. Implementing the inevitable engineering change orders during production involved reassigning pins and rewiring fixtures only to the extent required by the changes themselves. The relatively limited number of pins permitted by this scheme easily met the needs of the time.

FIGURE 1. Shown here is the waveform of a driver programmed to drive 1.5 V under both no-load (blue) and load conditions (yellow). With a 6-Ω load condition, the voltage at the device under test reaches only 710 mV.

The increasing complexity of printed circuit boards, however, began to strain tester resources. New boards often had more pins than testers could accommodate. Tester manufacturers began to provide additional pins, but the need expanded more rapidly than the testers' ability to address it. In addition, the cost of providing a driver/sensor for every pin and the resulting power consumption by a test system made this approach very expensive.

To reduce costs, tester manufacturers began to compromise on test-pin performance, replacing compo-

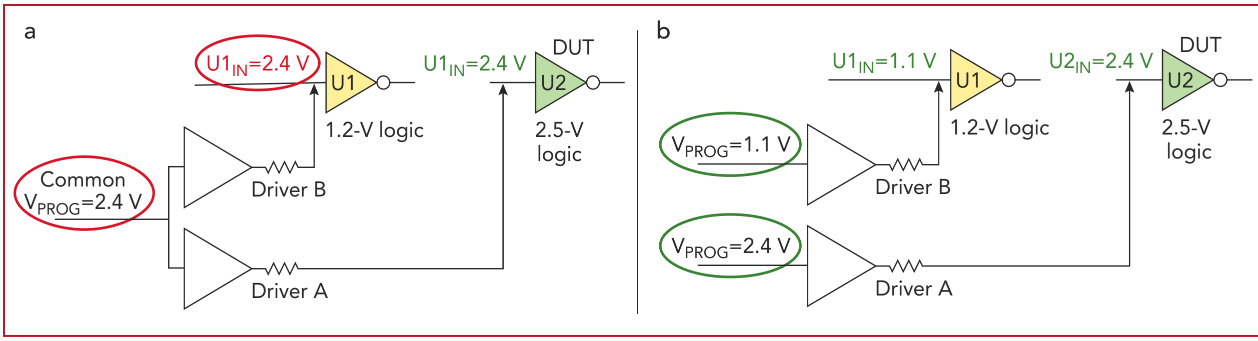


FIGURE 2. a) Assigning logic levels in groups of pins can compromise tests on mixed-logic boards, with a tester forcing damaging 2.4-V levels on 1.2-V devices. b) Testers that have independent per-pin programmable logic levels prevent overvoltage conditions.

nents such as drivers and sensors with less-accurate models. Unfortunately, these compromises also increased the likelihood that board defects would not be detected until later (and more expensive) test stages or—worse—until the product had shipped to customers. And none of these changes addressed the ever-increasing number of pins required to test the newest boards.

Consider some of the compromises and their implications:

• **Less accurate drivers.** To ensure accurate voltages at the device under test (DUT) under all load conditions, a tester should employ a closed-loop, low-impedance driver designed specifically for in-circuit testing. To save money, a tester manufacturer may use off-the-shelf, high-output-impedance drivers, but in these drivers, the actual voltage at the DUT depends heavily on how much current the driver requires to achieve the programmed voltage. The voltage applied during a test can vary considerably depending on the nature and state of the net.

The screenshot in **Figure 1** shows the waveform of a driver programmed to drive 1.5 V under both no-load and load conditions. With a 6-Ω load condition, the voltage at the DUT reaches only 710 mV.

Suppose the tester tells a driver to send an input high. The driver can deliver an accurate voltage only as long as the output pin connected to that same driver is either shut off or is also high. If the driver tries to send an input high and the output pin is driving low, the actual voltage at the input pin will be much less. Debugging that test—and achieving a reliable repeatable test—becomes much more difficult. In addition, testers will not generally report the actual voltage at the driven pin. Few people will take the trouble to attach an oscilloscope to the pin (and every other questionable pin) to measure the voltage.

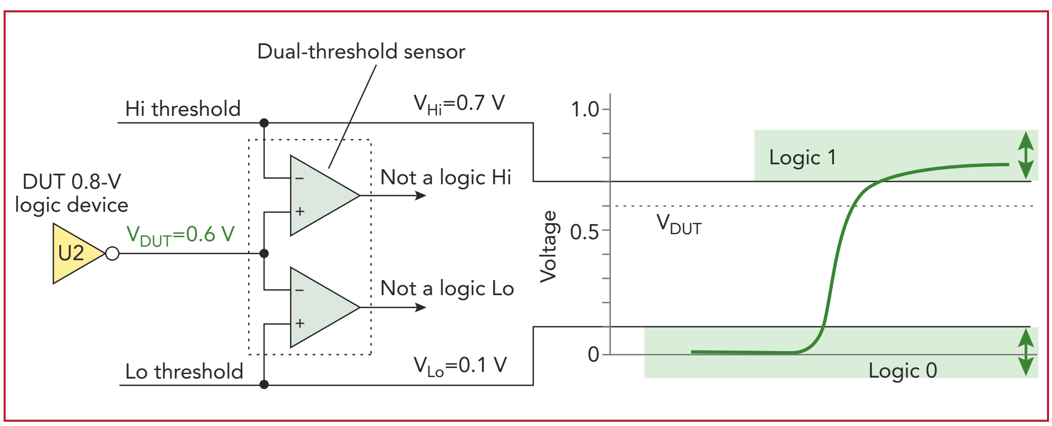


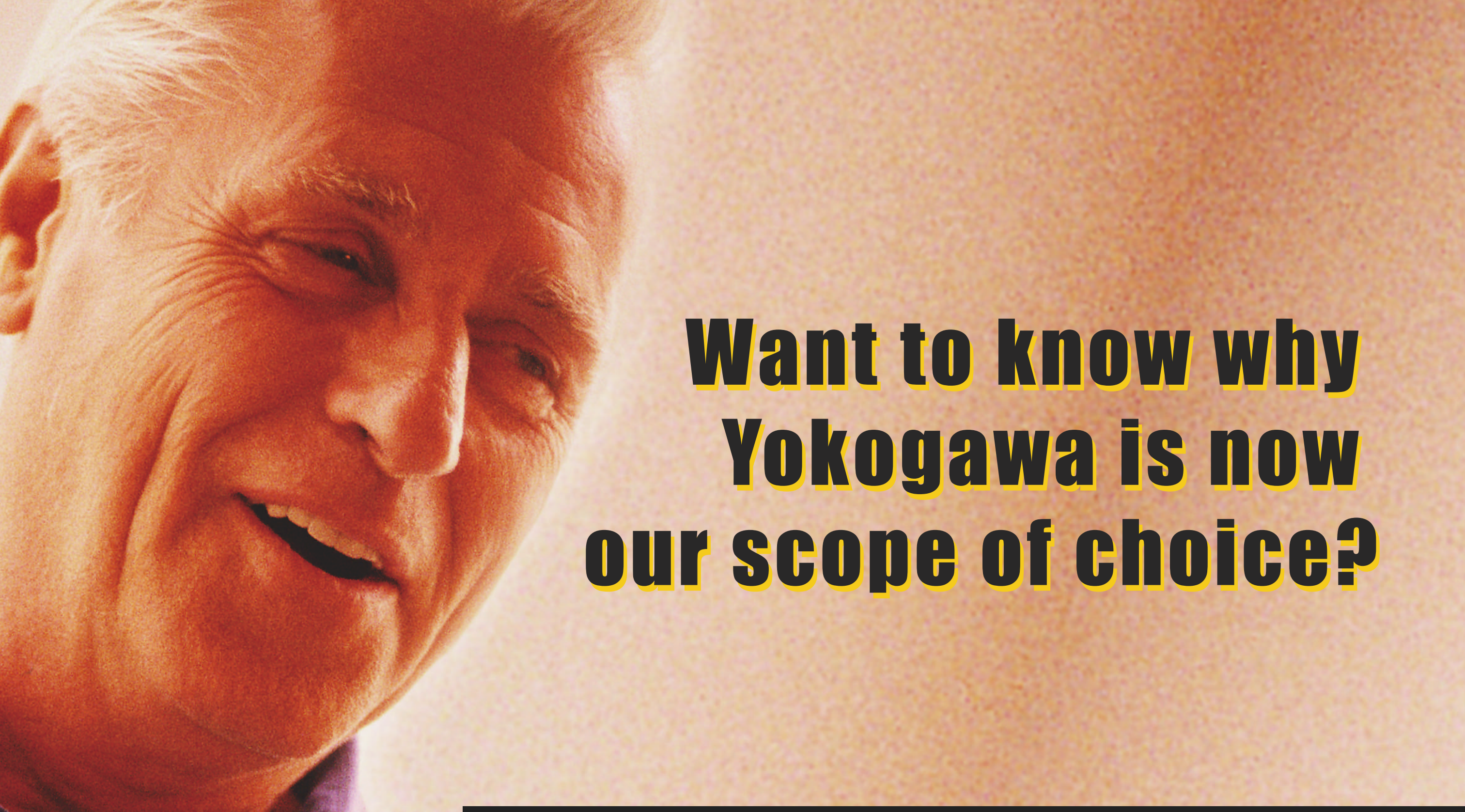
FIGURE 3. A dual-threshold sensor design identifies incorrect or marginal logic levels on a board under test.

Even if the tester can adequately drive pins on a good board, a board fault complicates the situation further. An open enable pin, for example, forces the tester to back-drive outputs that are no longer disabled. The resulting inaccurate voltages can cause false failures.

• **Less accurate sensors.** Most in-circuit testers rate their sensor measurements with margins of either ±100 mV or ±200 mV. Therefore, an IC output driving 700 mV can appear to the sensor to be between 600 mV and 800 mV or between 500 mV and 900 mV. With digital logic at 3.3 V or more, such a discrepancy may prove acceptable.

On the other hand, many devices operate much lower than 3.3 V. These low-voltage technologies may set highs at 1.2 V or even less. At these levels, the "slop" in the sensor's detection can produce unrepeatable, unreliable tests. In addition, such uncertainty means that running the same test on two different (but allegedly identical) testers may not give the same mix of passed and failed boards. Reliable testing of low-voltage parts, therefore, requires an in-circuit sensor with margins as low as ±15 mV.

• **Limited logic levels.** Assigning logic levels in groups of pins can compromise tests and even damage parts on mixed-logic boards. Consider the test illustrated in **Figure 2a,** in which the tester forces both U1 and U2 to the same voltage levels. Unfortunately, a driving voltage that accommodates U2 subjects U1 to a dangerous overvoltage condition. Testers that have independent per-pin programmable logic levels, as shown in **Figure 2b**, pre-



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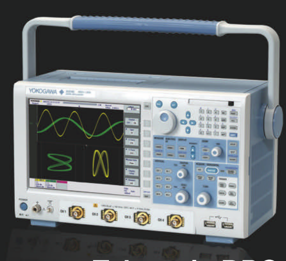

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Math channel(s)	4	1
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Serial bus analysis (CAN, I^2C and SPI)	View data tables from 2 buses together, in real-time	View the data table of only 1 bus at a time

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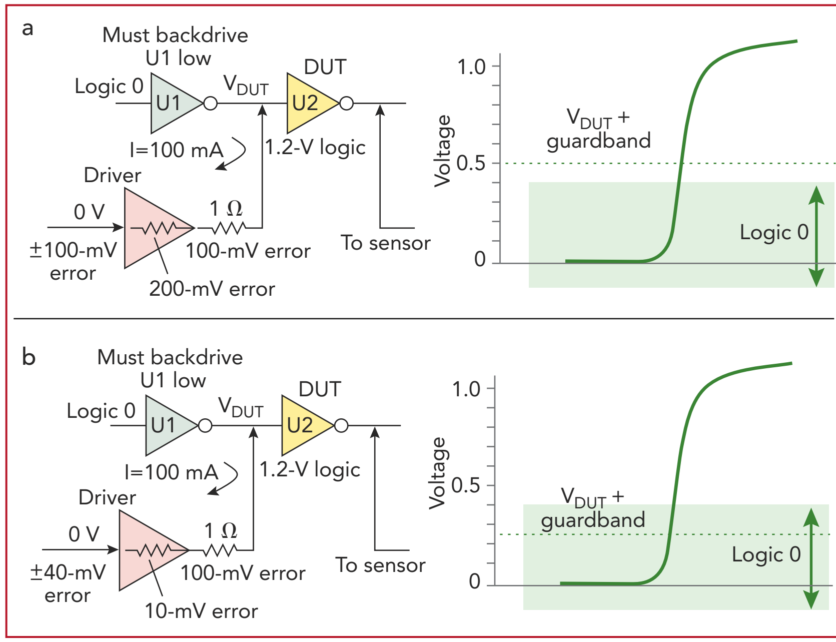


FIGURE 4. a) A unidirectional driver configuration renders U2 untestable because a programmer can't program the output voltage to anything less than 0 V to reduce U2's input voltage. b) A bidirectional driver overcomes this limitation and can reduce noise margins.

vent overvoltage conditions by assigning voltages to each device pin individually depending on its technology, so it will remain within a safe operating range.

Limited logic levels can make debug more difficult as well. One manufacturer, for example, found that he couldn't change the programmed logic level on one particular pin without changing the level for all 32 pins in that group. He had to assign that pin to another group by adding a wire to the test fixture.

- **Single level thresholds.** Defining only a single threshold to denote the transition from 0 to 1 ignores the fact that most devices have VOH_{MIN} and VOL_{MAX} specifications that create a gray area between the two. With a single threshold, a test cannot detect a faulty output transistor that can't drive high enough or low enough for reliable operation of the board in its target system. The board would have to proceed to functional or system test where diagnosing it would be more difficult. Dual-threshold sensors (**Figure 3**) don't have this ambiguity, so they can verify that the output transistors are functioning according to the manufacturer's specifications.
- **Unidirectional drivers.** Unidirectional drivers always define a low voltage at ground. This hard limitation reduces program debug flexibility and prevents users from adjusting a program so the board under test can compensate for noise that can trigger undesirable logic transitions. It also prevents the tester from dealing with negative-voltage technologies such as emitter-coupled logic (ECL).

Figure 4a shows a unidirectional driver. The driver inaccuracy plus the guardband totals 500 mV, and the maximum low input for U2 is 420 mV. In this configuration, U2 is untestable, because the programmer can't program the output voltage to anything less than 0 V.

In contrast, the driver inaccuracy and the guardband of the bidirectional driver in **Figure 4b** total only 250 mV. Again, the maximum low input of U2 is 420 mV. In this case, U2 is testable even without reprogramming the logic low to –0.2 V, but adjusting the bidirectional driver can reduce noise margins.

- **Fixed slew rate.** Different device technologies often require different slew rates. In fact, some devices will not operate consistently unless the slew rate of the driving signal exceeds some minimum. Slew rate also affects the amount of signal ringing and noise. Generally, the faster the edge, the more likely it is

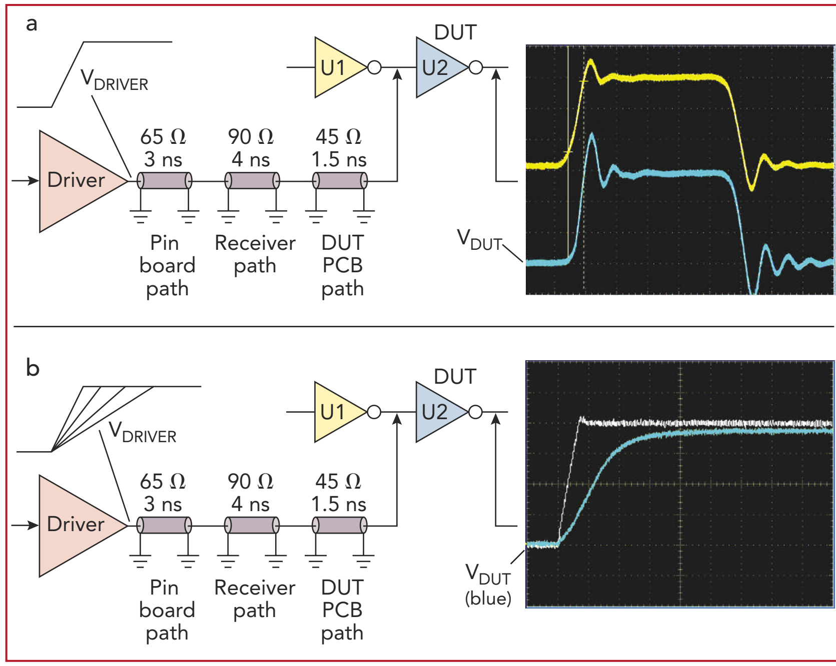


FIGURE 5. a) A fixed slew rate, such as the 300-V/µs edge rate, is too fast for some applications, where transmission-line effects will cause overshoot and ringing. b) An in-circuit driver with a fully programmable slew rate can optimize the waveform at a DUT to alleviate these problems.

that the signal will experience overshoot or ringing. Inductance and impedance in the fixture wiring also limit the slew rate.

A fixed slew rate, such as the 300-V/µs edge rate in **Figure 5a**, is too fast for some applications. Transmission-line effects will cause overshoot and ringing, and the user cannot lower the edge rates to eliminate potentially dangerous overvoltage conditions. **Figure 5b** shows how an in-circuit driver with a fully programmable slew rate can be used to optimize the waveform at the DUT.

• **Limited system power.** Device packages may include hundreds of signal pins. Required back-drive currents can exceed 250 mA per pin. Because real pin systems allow programmers to drive all pins in parallel, the total of the back-drive currents may exceed the limited power capacity of some systems. In that case, the drivers will fold back and will not reach their programmed voltages, producing false failures. Therefore, the actual number of pins that the tester can drive in parallel is application-dependent. Programmers should be aware that the limited system power ratings of some "pure-pin" systems can prevent simultaneous driving of tester pins when heavy back-drive conditions are involved.

Multiplexing to the rescue

To address some of the cost and pin-count issues while maintaining the maximum pin quality and performance, some tester manufacturers offer multiplexed test pins. Multiplexing allows test instruments to be shared (or pooled) among many (usually eight or 16) test points, and it expands the number of test points at lower cost. Without the need to support a test instrument behind every pin, multiplexed testers generally offer greater pin capacity and consume less power. Many also offer higher-performance pins.

Unfortunately, multiplexing does have drawbacks. It places additional restrictions on test program and fixture development. Programming becomes more complicated because a measurement cannot randomly assign the drivers/sensors and instruments that will be used during each test. Developers need to use nail-assignment software to analyze the tests and resolve any conflicts before building a fixture. *(continued)*

For tests that require numerous test points, you may not be able to find enough drivers and receivers to perform the measurements unless you assign test points that are spread out. This will result in increased path lengths between the tester nails and the device pins, which may increase noise and signal delays and make initial verification of fixture pin assignments more difficult.

Large devices on the board may have more pins than the tester has real pins available, so you may have to break the test into multiple bursts. To perform basic debug tasks, such as adding guard points and implementing engineering changes, you may have to reassign test pins and rewire the fixture, so the effort and cost of implementing any changes increases.

Which way to go?

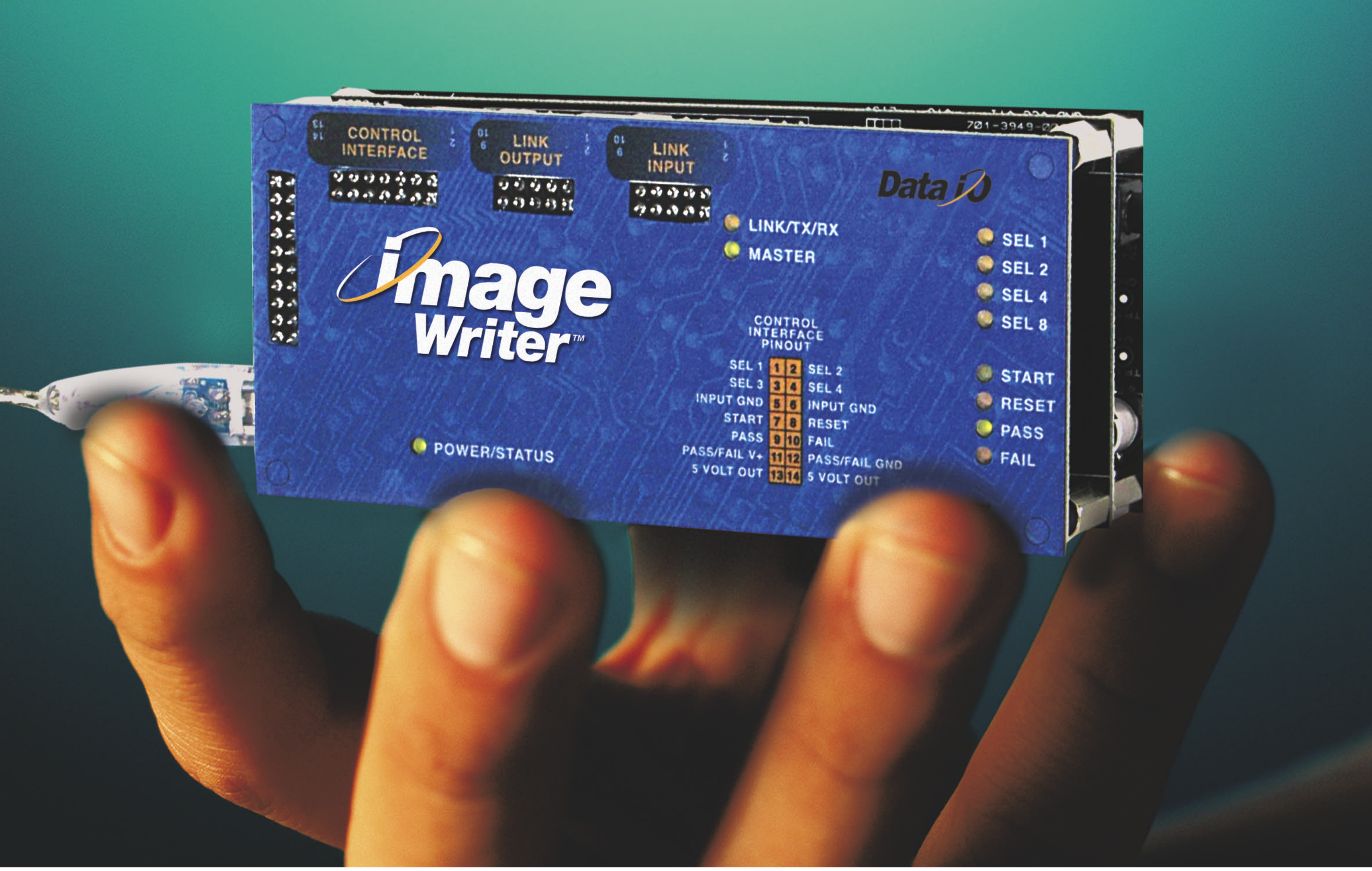
Multiplexed and pure-pin (or "nonmultiplexed") architectures will both work in most situations (as long as they both use high-performance pins). Test-program development times may be slightly longer for muxed systems, but many users are comfortable with them and prefer them because of their generally lower price. High-performance nonmuxed systems can be more expensive, but they permit faster and easier program development.

Needing to test a high-pin-count board will tip the balance toward the multiplexed systems. Providing enough real pins to test a board containing more than, say, 4000 nodes is neither cost efficient nor energy efficient.

Lower-pin-count applications requiring fast development or development by less-experienced users would favor the pure-pin solution. If you go this route, you can choose test platforms that let you easily move between pure-pin and multiplexed tests. See "The best of both worlds," in the online version of this article for more information about one tester that offers this option, www.tmworld.com/2006_11. T&MW

Alan Albee *is an in-circuit test product manager at Teradyne where he applies his 23 years of test engineering and applications experience.*

Anthony Suto *is Teradyne's chief scientist responsible for the Assembly Test Division's ICT and AXI technologies.*



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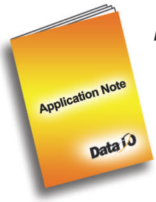

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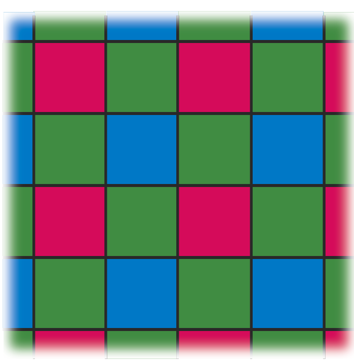


FIGURE 1. This pattern of colors, found in a Bayer-type filter, overlays a CCD in a color camera. Each colored element covers one photosensitive detector, which corresponds to a pixel in a final image.

For most machine-vision applications, monochrome—or gray-scale—images provide sufficient information about component placement, orientation, and shape.In some cases, though, color images add an extra "dimension" that improves inspection results.

In the electronics industry, the use of color-vision systems lets test engineers monitor the placement of colored components, differentiate between components and assemblies, and perform other inspections that rely on colors. One application might require a vision system to merely distinguish between a blue connector and a red one, without determining the exact shade of blue or red plastic the connector manufacturer used. In another case, an inspection of keyboard backlights or miniature LCDs may require careful matching of measured colors against standard reference colors.

Adapting a machine-vision system to take advantage of color imaging involves more than simply replacing a monochrome camera with a color camera.You must carefully assess camera characteristics and lighting requirements before jumping on the color-vision bandwagon.

Two types of CCD cameras

Most color cameras used for inspection tasks fall into two categories: those that use one charge-coupled device (CCD) and those that use three to convert light into electrical signals. In a 1-CCD camera, a transparent color-filter matrix overlays an array of light detectors. Each detector, which corresponds to a pixel in the resulting image, has a minute red, green, or blue "window" above it (**Figure 1**). A 3-CCD camera includes an individual CCD for each color (red, green, and blue). Because 1-CCD cameras predominate in machine-vision systems, I will cover them exclusively in this article.

Dr. Bryce E. Bayer of Eastman Kodak developed the arrangement of colors shown in Figure 1 so cameras could use one CCD to detect colors across a broad spectrum of visible light. Bayer's standard pattern uses twice as many green filters as red or blue filters to mimic the light sensitivity of the human eye. Color cameras found in machine-vision applications use CCDs with the same Bayer color-pattern arrangement, even though computers and software have no inherent "spectral response" to light. (Camera vendors also offer other filter arrangements.)

You may wonder how a camera can create an image of colored pixels if individual detectors respond to only one color of light. Vision equipment relies on math to fill in the "missing" colors for each pixel that will appear in a final image.

"Color-sensor vendors place a color-filter array over the sensor's individual detectors, or pixels. If you have a pixel with a green filter, the incoming light may contain red and blue wavelengths that pixel cannot detect," explained Steve Kinney, product manager at JAI Pulnix. "So, the camera looks to neighboring pixels to provide the needed information so it can approximate the other two color values for a given pixel." (See "A 'pixel' has two meanings," below.)

That approximation, or interpolation, can involve color information from several nearby detectors, or it can use color information from a 3x3 or 5x5 matrix of detectors around a central detector. Suppose orange light falls on several nearby detectors, as shown in **Figure 2**. That light generates a large signal from a central red detector, a medium signal from surrounding green detectors, and a tiny (if any) signal from surrounding blue detectors. By interpolating the light values from the central detector and its eight surrounding detectors, the camera would create a new color value for the red detector to indicate it had received orange light. As a result, the pixel on the final image would appear orange.

Keep in mind the analog-to-digital converters (ADCs) internal to a 1-CCD color camera produce an 8-bit or 10-bit value that corresponds to the amount of light that reaches *each* detector. Mathematical interpolation creates a new 24-bit or 30-bit value for each pixel in the resulting image.

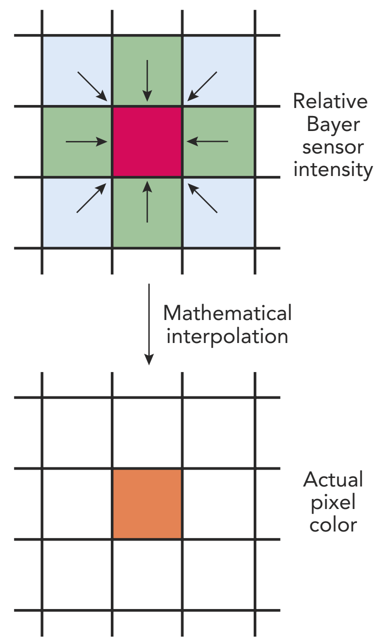


FIGURE 2. Software combines red, green, and blue color information from a central detector and the detectors that surround it to interpolate the color value for the resulting image pixel. Although each detector produces an *n*-bit value for its measured color, the interpolated color information for each pixel comprises 3*n* bits.

A monochrome camera with a 600x400 array of detectors, for example, produces 240,000 bytes per image. A color camera with equivalent resolution produces 720,000 bytes per image. (Both examples assume an 8-bit ADC.) So, when interpolation takes place within a color camera, your host computer must handle an image data rate that is about three times the rate for an equivalent monochrome camera. (CCD configurations of detectors are not always equivalent, so the 3X factor can vary slightly.)

Instead of putting out interpolated color values, some progressive-scan color cameras used for machine-vision applications provide "raw" color data from the individual red, green, and blue detectors. "Do not store that raw information in a JPEG or other compressed format," warned Kinney of JAI Pulnix. "Compression will ruin the unprocessed color information for an image."

Software in a host PC will interpolate the pixel values to produce a final color image for processing. Keep in mind the computer time needed to convert raw data into final images. Often, a basic PC cannot keep up with a 60-Mbytes/s flow of raw 8-bit color data, because it also must interpolate that information to create a new 24-bit value for each pixel in a color image. The interpolation creates pixels at a rate of 180 Mbytes/s.

In some applications, you might use only the raw monochrome output from a color camera to inspect the majority of a PCB to, for example, detect the position or orientation of ICs or determine whether components are missing. You could then perform a color-interpolation on only the small areas of an image for which you need color information. Thus, software will look for a red or green connector only in the spot where the connector should exist. (See "Monochrome cameras sense colors," p. 52.)

Images lose resolution

Be aware that you will lose resolution when moving from a monochrome camera to a color camera with an equivalent-sized CCD. Developers often ask camera suppliers to specify how much resolution an image will lose, but the vendors cannot quantify it. If you have a black-and-white edge, you have no color on the black side and all colors on the white side, so regardless of color, detectors are on or off. In that case, you don't see much effect from interpolation in the final image, and the edge appears sharp. (Adjacent high-

A "pixel" has two meanings

People who work with image sensors, color cameras, and color imaging often use the word pixel, short for picture element, to describe two different things: an individual light detector on a CCD and the smallest picture element in an image. For clarity in this article, I have used "detector" to indicate an individual detector on a CCD sensor, and I have used "pixel" or "image pixel" to identify the smallest color-picture element. —*Jon Titus*

FOR MORE INFORMATION

"Device Performance Specifications," Revision 2.0, MTD/PS-0719, Eastman Kodak. January 2006. www.kodak.com/go/imagers.

Graf, Rudolf F., *Modern Dictionary of Electronics*, 6th ed., Newnes, Boston, MA. 1997.

contrast colors such as blue and red also produce sharp edges.)

But, explained Kinney, if your color camera views similar colors, such as an orange object on a brown background, the interpolation will "mix" colors from nearby detectors. "So, the edge blurs and you lose resolution," he said, "but you can't tell in advance how much you lose." Some color-interpolation algorithms include edge-detection algorithms that aim to preserve the fidelity of edge information.

Unfortunately, the algorithms may cause a problem: They can remove the defects you want an inspection to reveal. Suppose you have a defect that appears in two or three pixels along a sharp edge. The algorithm "sees" the defect and removes it to "clean up" the edge. You need to pay attention to how software processes images and how that processing can affect results. Often, less-complex algorithms can quickly find defects in an image, even though they do not produce eye-pleasing images.

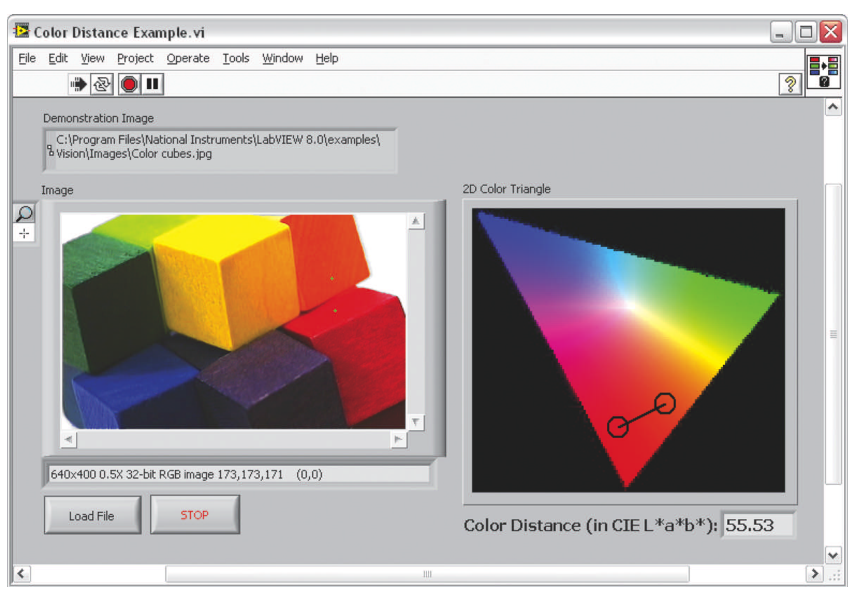
Lights should match color needs

Unlike monochrome vision systems that simply detect brightness levels across shades of gray, color systems depend on carefully controlled light sources. These sources should maintain a constant intensity and color output, or color temperature.

If you have little or no experience with lighting for a color-inspection system, seek professional advice from lighting vendors or system integrators. Vendors offer a wide range of light sources for a reason: Conditions and requirements vary so much that a small selection of light sources cannot meet all color-inspection needs.

Your choice of light sources will depend on what you want to inspect. "If you need to find a red object and do not need to match an exact shade of red, you may accept some light variations," said Kyle Voosen, vision product manager at National Instruments. "But if you must measure the color to ensure it matches a production specification, you need lights that produce a known spectrum and maintain it for a long time."

Halogen lights, for example, produce illumination across a continuous span of wavelengths. Some light sources, though, offer less than meets the eye. Although some LEDs create what looks like white light, their output may lack energy at several wavelengths. And as the phosphors in white LEDs age, the wavelengths of the "white" light shift. Those changes affect the colors a camera captures. *(continued)*



The right side of this screen display shows all colors available in a red-green-blue color "space." A point on the orange block and another on the red block translate to the two points shown on the color-space diagram. This type of information assists during system setup and color matching. Courtesy of National Instruments.

"The intensity of some light sources decreases as they age," noted Brent Runnels, systems engineer at National Instruments. "Many illumination products now include a feedback system that maintains a stable light output, even as a bulb changes its characteristics over time. Metal-halide lights also can change color over their life."

How you plan to use a camera will also affect your choice of lights. Monochrome cameras may take advantage of strobe lights that produce high-intensity bursts of light.

"You should approach gas-discharge lights such as fluorescent lamps or strobe lamps with care when you plan to use them with color cameras," said Richard Erickson, senior product manager at Hitachi Kokusai Electric America. "These lights have characteristics that affect their brightness and color temperature as they turn on or off. If you capture images as a lamp turns on, turns off, and in the middle of a flash, the images will show different colors for the same target." You could try to synchronize lamp and camera triggering, but some color cameras do not allow for an external trigger. They only operate in a free-run mode.

Generally, a white "target" illuminated in a camera's field of view provides a known reference for color settings. "For a color camera that produces an 8-bit value, you illuminate the white target and adjust the camera so the ADC for each color puts out a full-scale value of 255 for every detector," explained NI's Runnels. To avoid saturating the detectors, you could "back off" the balance adjustment so each ADC produces a value of less than 255, say 250, for white light. Then, you can set the image-analysis software so it knows the value of 250 for each color represents the contribution from white light.

"If your lights or inspection setup change, you can put a white target in front of your camera and acquire a new image to calibrate the color-balance settings," noted Runnels. "If you find specular reflections or glare from a product routinely saturate detectors, you could change to diffuse illumination, add a polarizing filter, or take other measures to avoid saturating detectors. Or, you may not care about saturation if it occurs in areas you don't need to inspect." T&MW

Monochrome cameras sense colors

In some applications, a monochrome camera can acquire an image that reveals color information. The use of colored lights and filters lets software determine color differences.

Brent Runnels, systems engineer at National Instruments, explained that using a red light source and a red filter with a monochrome camera makes a red label appear bright and a blue label appear dark. Even though the imaging system cannot determine the color of the labels, it can tell the difference between a red and a blue label.

Of course, this example assumes the PCB production facility would not have green labels available, because they would confuse the vision system. Green and blue labels would each appear dark, so a green label might pass inspection.

This monochromatic approach keeps the cost of a vision system low, and a monochrome camera can provide better spatial resolution than a 1-CCD color camera with a similar number of detectors. And on the software side, monochrome images require less processing than do color images.—*Jon Titus*

ACKNOWLEDGMENT

Thanks go to Jim Roselius, national sales manager at Panasonic Medical Vision, who also provided information for this article.

Test & Measurement World

MACHINE-VISION & INSPECTION

TEST REPORT

More versatile x-ray inspection

Steve Scheiber, Contributing Technical Editor

About a year ago, Teradyne introduced ClearVue, the company's latest entry into the 3-D x-ray inspection sweepstakes. The technology reduced inspection time, false calls, and overall cost of ownership compared to previous imaging techniques. *Test & Measurement World* awarded ClearVue one of its "Best in Test" awards for 2006. I recently asked Paul Groome, manager of Teradyne's automated x-ray inspection product group, for an update on the technology.

Q: What features have made the biggest impact on your customers?

A: Because of its approach to image acquisition, ClearVue allows the versatility of analyzing image data in either 2-D or 3-D formats on a single platform, depending on the situation. Manufacturers can obtain high-quality imaging of obscured components and BGAs and perform simpler tasks such as verifying accurate component placement and solder volumes in one pass. Companies have also been attracted by the product's high reliability.

INSIDE THIS REPORT

Q: What applications have benefited?

A: The technique has proved very popular in applications that value quality over all other product characteristics—automotive, telecommunications, datacom, and military/aeronautics environments, for example.

Q: How has the approach affected the demand for older x-ray solutions?

A: To draw an analogy we are all familiar with, I would say that the transition between conventional laminography and ClearVue puts us in the same position that consumers were in when electronics manufacturers introduced compact discs in the 1980s to replace vinyl LPs. As with all technologies that suddenly and completely alter the landscape, many die-hards kept their vinyl LPs, but they also bought CD and MP3 players. Nevertheless, the migration—however much people may resist it—is inevitable.

People compare ClearVue's repeatable, accurate, digital approach to the noisy, mechanical, analog alternatives. Still, many manufacturers continue to use laminography systems, and the technology has a lot of life left. Until now, it was the only viable 3-D x-ray solution. People understand both its strengths and its limitations.

Q: What about the future?

A: Projected growth rates through 2010 for automated x-ray inspection (AXI) will top 16%. With other automated vision and test solutions experiencing growth of less than 8%, it is clear that the demographic is shifting away from those more traditional inspection approaches to x-ray. And although our 2-D solutions have enjoyed considerable success, the addition of 3-D imaging is generating considerable excitement.

Paul Groome
Manager
Automated X-Ray Inspection
Teradyne
Courtesy of Teradyne.

Q: What's causing all the "buzz"?

A: Customers are excited by the fact that the x-ray sources don't have to move. This architecture simplifies the system's mechanical design. The resulting increased reliability and reduced downtime contribute significantly to companies' bottom lines.

Q: What improvements would you like to see in the technology going forward?

A: To be honest, the system addresses the needs of manufacturers for whom quality is the highest-priority concern, but determining how to apply it in a specific situation often requires a higher skill level than we might like. We'd like to make it easier to use. □

For more Q&A with Paul Groome, including an explanation of how companies choose between 2-D and 3-D x-rays, see "X-ray approach depends on application," at www.reed-electronics.com/tmworld/article/CA6375159.html.

EDITOR'S NOTE

Machine vision gets soft

Steve Scheiber, Technical Editor

Once upon a time, selecting an inspection system meant evaluating different hardware offerings. You chose a technology, such as x-ray or AOI, and looked for a machine whose features and capabilities matched the requirements of your operation. The speed and quality of image analysis depended on the system's attainable field of view, the x-y travel of the camera or unit under test, and the hardware's acquisition speed.

The explosion of computing power has changed this emphasis. Image-acquisition and data-transfer rates have increased dramatically. Memory and disk storage—while not free—no longer limit image quality. And the gating issue has moved from how fast you can gather data to what the system can do with data—in other words, from the hardware to the software.

All three features in this Test Report reflect this migration. On p. 55, Paul Groome talks about software that can analyze the same x-ray data as either 2-D or 3-D images. The story on phoenix|x-ray (p. 60) also emphasizes the various ways that software can manipulate the same data. And the primary achievement of MVTec is an environment for developing machine-vision applications (p. 58).

The capabilities of computing hardware will continue their inexorable advance. Advances in technology will continue to depend more on the imagination of people finding new ways to exploit that power than on the power itself. □

Contact Steve Scheiber at sscheiber@aol.com.

HIGHLIGHTS

Nanometrics unveils photoluminescence mapping system

Nanometrics, a supplier of integrated and stand-alone metrology equipment for the semiconductor industry, has introduced the VerteX rapid photoluminescence (PL) mapping system, which is used for compound semiconductor production control during volume manufacturing of optoelectronic devices such as LEDs.

The company claims the tool marks the first automated PL mapping system that accurately predicts emission wavelengths for green LEDs at the wafer level. The VerteX PL represents Nanometrics' initial product launch since completing its acquisition earlier this year of Accent Optical Technologies, a supplier of overlay and thin-film metrology and process-control systems.

VerteX's control of laser-excitation conditions allows for accurate matching of PL data to electroluminescence (EL) test information, resulting in faster run-to-run epitaxial layer growth feedback to enable the predictive metrics required for volume production of LEDs, particularly green LEDs. With most systems, the exact emission wavelength of a green LED can only be measured by an electrical test after the wafer has been fully processed. VerteX, however, can forecast diode performance before the wafer is fully processed, providing the data needed to actively adjust process controls for optimal epitaxial layer growth—the yield-limiting step in LED production.

Nanometrics says that the tool also can be used during the manufacture of a range of optoelectronic materials, including ultraviolet (UV) diode lasers for high-definition DVD and Blu-Ray optical disc appliances.

"As production volumes increase and tolerances tighten for epitaxial

EMVA releases GenICam 1.0

In September, the European Machine Vision Association (EMVA) officially released version 1.0 of its GenICam standard, which defines a generic programming interface for machine-vision cameras. The standard makes it possible for developers to use a single piece of code to configure cameras produced by different vendors and equipped with various interface technologies, such as IEEE 1394, GigE, or Camera Link.

To support GenICam, a camera vendor must supply a "camera description file" that uses XML syntax to describe the mapping of the camera's high-level features (such as gain or exposure) to its low-level registers. The GenICam standard group created a C++ reference implementation that reads the camera description file and provides a unified application programming interface (API) for the camera.

The API reflects all of the features described in the camera description file. As a result, when new features are added to a camera and to its description file, the features are immediately available via any software product that supports GenICam.

EMVA says that the GigE Vision standard should also give a boost to GenICam, because GigE Vision relies on GenICam to achieve interoperability between Gigabit Ethernet based cameras. To comply with GigE Vision, a camera must provide a GenICam camera description file. www.emva.org.

layers, customers demand a metrology tool that not only provides accurate measurements, but that can provide the processing data required to accelerate time to yield," said Tom Ryan, Nanometrics' product manager for compound semiconductors.

Ryan added, "In the case of LED processing, VerteX makes possible accurate predictive processing metrics of green, blue, and UV LED emission wavelengths at the wafer level...This system also demonstrates Nanometrics' commitment to the emerging markets for LEDs, such as backlighting for LCD TV displays, automotive headlights, and solid-state lighting."

The new VerteX product complements Nanometrics' portfolio of wafer-inspection systems, including the RPM2000 desktop PL mapping system, and it adds another component to the company's closed-loop advanced process control (APC) capabilities, enabling Nanometrics to provide a predictive metrics strategy for its customers. www.nanometrics.com

Agilent enhances SJ50 inspection system

The Medalist SJ50 Series 3 automated optical inspection (AOI) system from Agilent Technologies expands on the company's SJ50 product line to help manufacturers cope with emerging technologies, such as 01005 components. The algorithms included in the system are designed to bring greater image clarity to low-contrast components, providing the end-user with better defect-analysis capabilities. Agilent says that the image clarity results in lower false-call rates and improved defect detection.

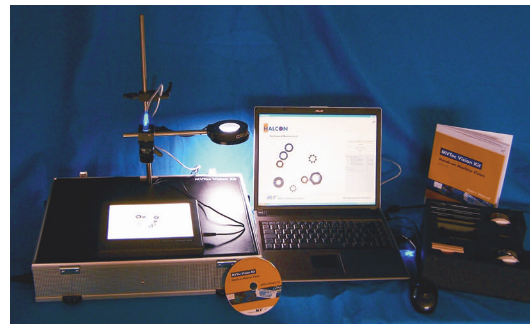
The Medalist can be deployed in a 2-D paste, pre-reflow, mixed-mode, and post-reflow environment, yet the optics head can be converted for use in inline 3-D solder paste inspection. Agilent also says that the system cuts inspection time by 50%. www.agilent.com/see/aoi.

Dalsa eliminates Coreco brand

Dalsa, a manufacturer of digital-imaging products, has announced that it is eliminating the Dalsa Coreco logo and brand from its line-up. All of the company's products will now be marketed under the Dalsa name. The Ontario-based Dalsa acquired Coreco Imaging in the spring of 2005. www.dalsa.com.

10 YEARS of machine-vision software

Steve Scheiber
Contributing Technical Editor



As *Test & Measurement World* celebrates our 25th anniversary in 2006, we join with other companies enjoying the fruits of their success. MVTec Software in Munich, Germany, for example, has spent the past 10 years developing machine-vision software tools for inspection applications.

MVTec began as a spinoff from the Technische Universität München (Munich University of Technology) in 1996. Still owned by founders Dr. Wolfgang Eckstein, Dr. Olaf Munkelt, and Dr. Carsten Steger, MVTec has doubled in size over the past three years, now employing more than 40 vision experts.

The company's primary achievement is the Halcon software library, which provides an integrated development environment for machine-vision applications. The tool offers more than 1000 inspection-related operators, and it interfaces with hundreds of image-acquisition devices. Platform independent, it accommodates Windows, Linux, and Solaris operating systems. The most recent version of the software safeguards all information about the programmer's code and algorithms as intellectual property and prevents anyone from changing them without the proper passwords.

Companion software ActivVision Tools serves Halcon users who would prefer to develop applications without writing Visual Basic code. ActivVision Tools present complete solutions for gauging objects, reading bar codes, and performing blob analysis. Programmers can work with both tools in tandem, using the friendlier environment where possible and resorting to the Halcon source when the preprogrammed solutions do not adequately address a problem.

One of the company's goals is to communicate as much of its expertise as possible to engineers who need to adopt vision tools. Eckstein said, "We build high technology. Only a few specialists have any idea what it can do. A company that works in a segment like this has to consider how to reach potential customers so they can make the most of its capability. Unfortunately, in our industry, such tools are few and far between. We wanted a tool to communicate this special knowledge without giving our audiences a headache."

To meet this challenge, Eckstein and his crew created the MVTec Vision Kit, which allows the company's distribution partners to demonstrate vision technology to potential customers. The Vision Kit consists of a camera, illumination devices, and sample objects from common production situations, all in an aluminum case. Assembling the pieces and plugging them into a notebook computer creates a simple machine-vision system that lets distributors perform demonstrations using examples that relate to the problems that engineers face.

The company sees this kit as the "missing link" in customer support. MVTec's experts can evaluate an application, help the customer visualize possible solutions using the kit, and provide customer training, thereby contributing to the ease of implementation in the manufacturing line. □

Automation: Its name is software

Steve Scheiber, Contributing Technical Editor

An x-ray inspection system obviously needs hardware that can acquire and transmit images quickly and accurately for processing. But the explosion of computing power in inspection systems has dramatically increased the importance of software, both for preparing the inspection regimen at one end and for analyzing the generated images at the other. And as happened with conventional test equipment a generation ago, software is rapidly becoming the "great differentiator" in inspection applications.

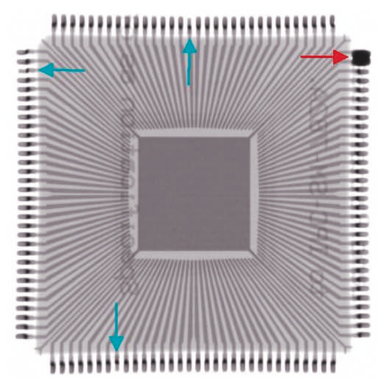


Fig. 1 The red arrow indicates a solder bridge. The blue arrows highlight nodes with insufficient solder.

Courtesy of phoenix|x-ray.

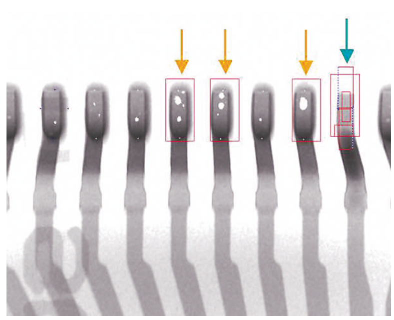


Fig. 2 In this detail, the blue arrow shows a joint with no solder. The amber arrows highlight solder voids.

Courtesy of phoenix|x-ray.

Software used for developing inspection applications must make it easy for engineers to set up numerous standard inspection scenarios and then redefine the scenarios as needed. Users also need the ability to instruct an inspection activity to be more or less comprehensive without changing the inspection program.

Consider manufacturing activities related to preproduction and ramp-up to full volumes. The number of defects for a given process should fall with time. Therefore, after the initial ramp-up, the production line may not require a full-blown inspection step most of the time. A comprehensive test on a subset of units and a cursory test on the rest should suffice.

This scenario is similar to a sampling scheme, but it allows a manufacturer to look for specific failures in particular parts of every assembly without unnecessarily taxing production-line throughput. An available "on-off switch" can permit users to decide how much of an inspection step to execute depending on changing circumstances.

An example product

With those goals in mind, phoenix|x-ray in Germany, working with Contax in the UK, developed the Xe^2 analysis software. The Xe^2 software (X-ray image Evaluation Environment) is a graphical development system that generates various measurement scenarios for analyzing 2-D images in real time.

During development of the inspection procedure, users can define new quantitative tasks, such as determining the mean gray-scale value of an image detail, as well as statistical analyses, such as the mean of a group of measurements. The x-ray images are taken with a 12-bit image intensifier or with a high-contrast (16-bit)

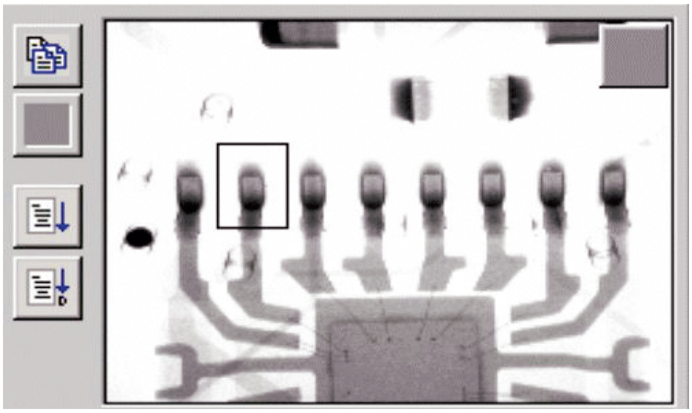


Fig. 3 This graphical representation shows the QFP test setup. The module permits the classification of gull-wing solder joints according to their width and average gray scale. A bridge check is also performed. A check of the heel fillet is optional.

Courtesy of phoenix|x-ray.

digital detector. By providing a graphical representation of the results, the system can provide a more visual picture of the quality of the product and the overall efficiency of the manufacturing process than could the raw data alone.

The Xe^2 software uses algorithms to determine the presence or absence of a physical solder joint on a surface-mounted device, look for voids and determine their criticality, and examine the level of wetting between a device and the board surface. The software analysis tool then allows users to further define pass and fail criteria using images as well as more conventional quantitative data input. The software can also allow users to manually define specific measurement results to be "good" or "bad," learning from those determinations how to make those same decisions automatically later with a minimum of false calls.

The phoenix|x-ray system includes some standard modules that address common failure mechanisms. A so-called quad flat-pack (QFP) module examines gull-wing solder joints on any type of device package, determining misregistration of the lead, the joint width, and the existence of the heel fillet and the toe fillet. It also measures the gray scale of the heel fillet and the solder joint itself, and it detects voids in the solder and solder bridges between joints on the board. Other standard modules inspect any type of solder joints on a quad flat-no-lead (QFN) package and classify plated-through holes.

Figure 1 shows an image generated by the QFP module. The red arrow highlights a solder bridge. The three blue arrows show leads containing insufficient solder. In the high-angle detail in **Figure 2**, the blue arrow indicates a joint with no solder. In the case of the voids indicated by the amber arrows, the system will calculate the void volume as a percentage of the volume of solder to determine whether it should consider the void a defect.

Also critical to the success of any software environment is the user interface. The interface must be easy to understand and must make it easy for users to set up tests and hone them as conditions change. **Figure 3** shows a graphical display of the test setup.

Manufacturers already express concern at the number of false failures flagged by inspection systems. The ability to analyze image data will continue to increase with the power of the controlling computers. Higher resolution and faster decision making will only have value, however, if the software can correctly differentiate between real failures and marginal conditions that should pass inspection. □

PRODUCTS

EM CCD camera

The ImagEM is the latest addition to Hamamatsu Photonics' C9100 electron multiplication CCD camera line. Designed for low-light fluorescence imaging, ultra-low-light luminescence imaging, and high-dynamic-range bright-field imaging, the camera has applications in materials research and industrial imaging.

The ImagEM features low dark current, stable high gain, and increased signal-to-noise ratio. The camera offers dark current levels down to 0.001 electrons/pixel/s with temperature stability of ±0.05°C at –80°C. Special features for use with real-time confocal microscopes are included. Proprietary synchronization modes allow synchronization to spinning disk and multipoint confocals, even if the disk speeds are not constant. Shading and banding effects are eliminated, according to the company.

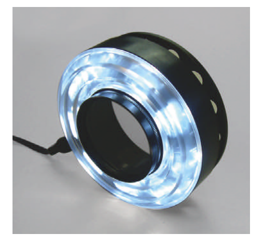
Another new feature is the built-in real-time image-processing functions for live recursive filtering, background subtraction, and shading correction. A built-in image processor handles high-speed streaming applications. Readout speed, camera gain, exposure time, triggering with time delay, and polarity control for external devices are all software controlled for integration into any application or setup. *Hamamatsu Photonics, www.imagemccd.com.*

X-ray inspection system

Comet has added the FeinFocus Cougar Pro to its line of x-ray inspection systems. Designed to enhance yield in surface-mount assembly processes, the Cougar Pro features automatic loading and unloading of parts as well as automated defect recognition (ADR) technology. The system moves parts from a conveyor belt and loads them into the preprogrammed imaging position; from there, the standard five-axes manipulator can control the sample for automated inspection. Inspection results can be viewed on the screen or in SPC data format. *Comet, www.comet.ch.*

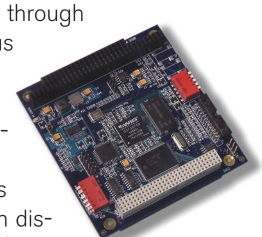
Polarized ring light

The RL-9, high-output LED ring light from Orled now includes a polarizing option that diminishes glare from reflective objects, such as the solder beads on assembled circuit boards. Light from the LEDs passes through a polarizing film before illuminating the object being inspected. The light bounces off the object and passes back through an analyzer in the ring light before arriving at the eye of an operator or the lens of a camera. Rotating the ring at the center of the light aligns the analyzer with the polarizer. Orled says the polarizing feature produces an image with less glare and more contrast. Price: $615. *Orled, www.orled.com.*



MPEG frame grabber

The Model 314 from Sensoray is a MPEG-1/2/4 and MJPEG frame grabber that captures full-frame (720x480) video at 30 frames/s. Uncompressed video is available through the PC/104+ bus for previewing.



The Model 314 has two synchronized audio input channels as well as on-screen display of text (OSD). It performs motion detection in three regions of interest, each of which is programmable. Bit rates range from 800 kbps to 10 Mbps. Linux, QNX, and Windows drivers are supplied, and a Fast Windows stream player is also available. Price: $328. *Sensoray, www.sensoray.com.*

Ruggedized imaging system

Intended for use under hostile conditions, such as vehicle-impact testing, the FastCam MH-4 miniature, remote digital video imaging system from Photron has a single processor that supports up to four detachable camera heads that can be mounted in areas where space is limited. Each head is just 35x35x35 mm and weighs less than 100 gm.

The FASTCAM MH-4 acquires images at a rate of 2000 frames/s at 512x512-pixel resolution or up to 10,000 frames/s at reduced resolution. High light sensitivity is achieved using an 8-bit monochrome, 24-bit color CMOS sensor with a 10-µm pixel size. Three cable types (90° right, straight, and 90° left) and two camera head connector configurations (top-mount and rear-mount) simplify mounting and placement of the camera heads. The tilting camera mount accommodates NF style lenses as well as an optional C-mount adapter.

FastCam MH-4 cameras are ruggedized to withstand high shock and vibration of up to 100 g on any axis, making them particularly useful for recording critical events during high-impact tests. *Photron, www.photron.com.*

CCD camera

Cooke has released a new version of its pixelfly qe camera with 1392x1024 pixels, high quantum efficiency of greater than 65%, and higher sensitivity with reduced noise of only 7e. The 39x39x68-mm camera offers a dynamic range of nearly 70 dB, and it is aimed at low-light, high-dynamic-range applications. *Cooke, www.cookecorp.com.*

2-Mpixel camera

The Adimec-1620 camera—the newest member of the Adimec-1000 family—is available in monochrome and color versions and is designed to handle low light conditions. A single-tap model handles 18 progressive images/s, while a double-tap version handles 34 progressive images/s. The 2-Mpixel camera also includes a standard Camera Link interface.

The camera can be used in automated optical inspection, wafer inspection, semiconductor inspection, and metrology. Offering a 1600x1200 resolution and 7.4-µm pixels, the camera's sensor can detect small details in a large area. *Adimec, www.adimec.com.*

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Test & Measurement World
225 Wyman St., Waltham, MA 02451
781-734-8423; tmw@reedbusiness.com

Editorial Staff
Chief Editor: RICK NELSON
781-734-8418; rnelson@tmworld.com

Technical Editor: STEVE SCHEIBER
sscheiber@aol.com

Advertising Sales
Publisher: RUSSELL E. PRATT
781-734-8417; rpratt@reedbusiness.com

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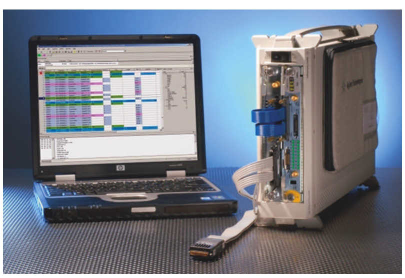
ADVERTISER INDEX

Analyze and exercise PCIe 2.0 signals

The PC industry is poised to double the speed of the PCI Express (PCIe) bus to 5-Gbps PCIe 2.0. To make sure that PCIe 2.0 devices work, you can use the E2960B protocol analyzer and exerciser from Agilent Technologies.

This modular bench instrument, which is controlled by an external PC, can capture and analyze data on PCIe buses that consist of one lane to 16 lanes. Because engineers often need to correlate bus activities with individual bits, the E2960B can connect to an Agilent 16900 series logic analyzer. Thus, you can view the PCIe bus from the physical layer to the transaction layer. The gateway software lets you set up a common marker that, when you move it on one instrument, also moves the marker on the other. You can also view the logic analyzer's display on the E2960B's host computer monitor and you can cross-trigger the instruments.



The E2960B gives you several probing options. You can insert a board into a PCIe slot to gain access to live bus signals. A midbus probe gives you access to the bus without interfering with signals, and it contains a resistor mounted in the probe to minimize capacitance. Three versions of the midbus probe are available that support various board layouts.

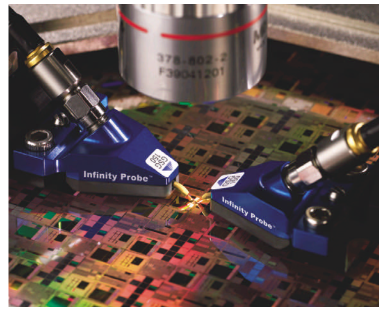
Base price: $47,600. *Agilent Technologies, www.agilent.com/find/pcie2.*

Wafer probes operates to 220 GHz

Cascade Microtech has announced enhancements to its line of Infinity probes, supporting finer pitches (down to 50 microns) and smaller contact areas (with pads as small as 25 x 25 microns) while extending the operating frequency range to 220 GHz.

The probes serve in semiconductor process characterization and can probe mixed-signal MOS devices used in wireless-communication applications. In addition, they can test high-frequency interconnects and devices such as amplifiers, mixers, oscillators, multipliers, and switches used in automotive collision-avoidance systems, satellite telecommunications, radio astronomy, spectroscopy, surveillance, and medical imaging.

The Infinity probe combines the vendor's proprietary thin-film technology with coaxial technology to optimize return loss, attenuation, and crosstalk specifications. Cascade Microtech reports that the microstrip transmis-



sion lines on the Infinity probe's thin-film tips confine fringing fields more tightly than conventional flexible coplanar tips, and the company adds that the resulting improved field confinement reduces unwanted couplings to nearby devices or other probe tips, thus increasing RF measurement accuracy.

The probes are also designed to optimize precision RF connections to aluminum pads on a wafer—a task that's more difficult than connection to gold pads. The Infinity probe's performance on aluminum pads, the company reports, is achieved by optimizing the key probe factors that affect contact resistance: tip contact area, force applied, tip metallurgy, and scrub. The force delivery of the Infinity probe is such that only a small horizontal motion (scrub) is necessary to break through the aluminum oxide to make contact with the pad. This, coupled with the Infinity probe's non-oxidizing tips, ensures minimal pad damage and superior contact on silicon devices with pads as small as 25x25 microns.

The Infinity probe is available in versions operating to 40, 50, 67, 110, 140, 170, or 220 GHz. Pitch sizes include 50, 75, 100, 125, 150, 200, and 250 microns.

Base price: $895. *Cascade Microtech, www.cascademicrotech.com.*

Fluke enters 6½-digit DMM market

Fluke 8845A and 8846A 6½-digit bench DMMs measure AC and DC voltage and current, two-wire and four-wire resistance, frequency, and period. The 8846A also measures temperature (with an RTD) and capacitance. Basic DC accuracy is 0.024% for the 8846A and 0.035% for the 8845A.

These instruments replace the 5½-digit Fluke Model 45, and they compete with the Agilent 34410A/34411A and the Keithley 2000. The 8846A has a front-panel USB port for flash memory devices. Both models feature a four-wire resistance, but with special probes that come with the instrument, you can make four-wire measurements with what seems like two leads. Each

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probe lead contains a second, embedded wire that connects both wires to the meter. Both meters feature front-panel and rear-panel test jacks.

You can use soft keys to invoke measurement functions such as statistics, histograms, and trend plots. Thus, you can perform some analysis without transferring data to a PC.

You can connect either meter to a PC through IEEE 488, Ethernet, and RS-232 ports. You can purchase a USB-to-RS-232 adapter cable and software for $200.

Base prices: 8845A—$995; 8846A—$1395. *Fluke, www.fluke.com.*

Modular scopes compete with stand-alones

The ZT4610 line of PCI, PXI, and VXI oscilloscope modules from ZTEC Instruments has specs comparable to midrange stand-alone scopes but consume less rack space—a plus if you're building a production test stand. The family consists of the two-channel ZT4611 for PCI, PXI (pictured), and VXI with sampling rates of 2 Gsamples/s on two channels. The four-channel ZT4612 for VXI only samples at that same speed when running four channels.

Both models let you interleave channels to double sample rates, and both feature a 1-GHz bandwidth. They also contain advanced triggering such as pattern, pulse width, state, and video with qualified triggers and holdoff settings.

Software support for the ZT4610 family includes drivers for C and LabView with both high-level and low-level routines so you can choose the level of control and programming complexity. The scopes also come with ZScope 2.0, a software application that lets you operate the scope through traditional controls for vertical, horizontal, and trigger settings.

Base prices: ZT4611—$7995; ZT4612—$19,995. *ZTEC Instruments, www.ztecinstruments.com.*

Agilent announces PSP model-extraction package

Agilent Technologies has announced what it calls the first complete and commercially available Pennsylvania State University-Philips (PSP) model parameter extraction package for advanced CMOS device models. The new package, for use with Agilent's Integrated Circuit Characterization and Analysis Program (IC-CAP) software platform, provides more accurate and efficient modeling than was possible with previously available solutions, according to the company.

(continued)

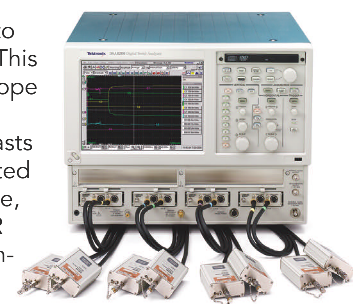
Semiconductor foundries use IC-CAP software to characterize foundry processes. With Agilent's PSP Model Extraction Package and IC-CAP, software designers can generate complete models based on the most recent version of the Compact Modeling Council's standardized PSP model. The package in-

cludes an easy-to-use interface for measurement collection, recommended extraction flows, and model implementation. Agilent's PSP Model Extraction Package has been verified with foundry data from several large CMOS foundries.

Base price: $15,000. *Agilent Technologies, www.agilent.com.*

TDR scope analyzes 12.5-Gbps data paths

When characterizing signal paths of multigigabit serial data paths, digital designers have had to move from using time-domain reflectometers (TDRs) to using more expensive vector network analyzers (VNAs). Recognizing that trend, Tektronix developed the DSA8200 digital signal analyzer that characterizes paths for digital data streams up to 12.5 Gbps. This sampling scope with a TDR function boasts 15-ps reflected TDR rise time, 50-GHz TDR and S-parameter measurements, and a 600-μV noise floor at 50 GHz. The company says the instrument is less expensive than a VNA and enables you to set up and perform measurements faster.



The DSA8200 consists of a mainframe and slots for four differential optical and electrical pairs. Two TDR heads reside at the end of 2-m cables that connect to the plug-in modules. Thus, you can keep the TDR head close to your DUT, and you can characterize up to four differential pairs. Sampling modules are also available.

Because the DSA8200 is a Windows-based instrument, you can use the company's IConnect software to measure return loss, reflections, eye diagrams, jitter, and crosstalk. A command-line interface lets you automate measurements through scripts.

Base prices: DSA8200 mainframe—$20,900; TDR modules—$27,100; sampling modules—$22,000; IConnect software packages—$7900. *Tektronix, www.tektronix.com.*

System Integration in Micro Electronics
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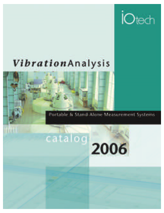
Vibration solutions catalog



IOtech offers a compilation of vibration-measurement applications for automotive, industrial, medical, and aerospace equipment. The WaveBook and ZonicBook series of measurement products are featured in these applications. *IOtech, www.iotech.com.*

Ultra LED testing

Ultra FINN, the latest innovation in LED color and intensity verification from Test Coach, features improved accuracy, increased speed, and even greater reliability, all in a miniaturized package. *Test Coach, www.testcoachcorp.com.*

Digital multimeters

The Fluke 8845A and 8846A 6.5-digit precision multimeters have the precision and versatility to handle your most demanding measurements. The high-performance meters are feature rich, yet are easy to use. *Fluke, www.fluke.com.*

Power quality monitor

Astro-Med has introduced a portable power-quality monitor and data-acquisition analysis system. The Dash 8XPM supports up to eight channels of inputs for single- and three-phase power-monitoring applications. *Astro-Med, www.astro-med.com/products/d8xpm.html.*

Calibrator and thermometer

The Model CL3515R is a portable calibrator/thermometer with a four-digit LCD. The NIST-traceable unit uses external K/J/T/E/R/S/N/L/U/B/C type thermocouples and features two channels for thermocouple temperature measurements with offset adjustment. Price $295. *Omega Engineering, www.omega.com/Temperature/pdf/CL3515R.pdf.*

GigE and Firewire cameras

The Basler Scout cameras feature Gigabit Ethernet (GigE Vision) and FireWire-b interfaces and are equipped with a selection of Sony CCD sensors ranging in size from VGA to 2 Mpixels. GigE allows cable lengths of up to 100 m. *Basler, www.baslerweb.com/scout.*

Digital patch panel

The Media Cross Connect modular digital patch panel allows uses to program a connection from any port to any other port. Designed for the test lab, the MCC is critical for achieving test automation. *MRV Communications, www.mrv.com.*

(continued)

CATALOGS & PRODUCTS

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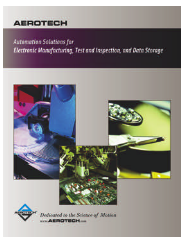
Design-for-test tools

Mentor Graphics provides a broad portfolio of design-for-test (DFT) solutions including scan, automatic test program generation (ATPG), embedded deterministic test (EDT), advanced memory test, boundary scan, logic built-in self-test, and a variety of DFT-related flows. *Mentor Graphics, www.mentor.com/products/dft.*

Motion solutions brochure



The *Automation Solutions for Electronic Manufacturing, Test and Inspection, and Data Storage* brochure from Aerotech presents motion-control/positioning solutions for electronic assembly, automated optical inspection, pick-and-place, PCB laser drilling and stencil cutting, and wafer singulation. *Aerotech, www.aerotech.com.*

USB test and measurement

Data Translation's 2006 USB Product Guide offers details on the company's broad range of USB data-acquisition products. You can choose from low-cost, simultaneous, high-performance, and DSP products. Free copies are available at www.datx.com/productguide. *Data Translation, www.datatranslation.com.*

Line-scan camera

Thanks to its 400-MHz (3200 MIPS) DSP, the new VC4002L line-scan camera from Vision Components is one of the fastest intelligent cameras on the market. *Vision Components, www.vision-components.com.*

AC power distribution

Pulizzi's AC power-distribution and control systems are rack- or strip-mounted with circuit-breaker protection, EMI/RFI filtering, spike/surge protection, system-remote power on/off, remote reboot, emergency shut-down, redundant (dual) power, sequential power up/down and power regulation. *Pulizzi Engineering, www.pulizzi.com.*

Large-format lens

Navitar's new 1X Raptar Pro large-format lens covers up to 90-mm sensors. It offers a high-resolution (100 lp/mm) F/4.0 design and is sized for a 12k line-scan camera. *Navitar, www.machinevision.navitar.com.*

Network analysis up to 40 GHz

The R&S ZVA40 network analyzer has a frequency range from 10 MHz to 40 GHz. The analyzer allows you to perform measurements on passive and active components as well as perform antenna measurements in radar and satellite applications. *Rohde & Schwarz, www.rohde-schwarz.com.*

(continued)

CATALOGS & PRODUCTS

The following write-ups were supplied by advertisers in this issue.

Ethernet switches

Advantech has launched a new category of "smart" industrial Ethernet switches. The EKI-6538 eight-port switch occupies a space in between the inexpensive unmanaged switch and the overly expensive fully managed switch. *Advantech eAutomation Group, www.eautomationpro.com/us.*

Harsh-environment lenses

Edmund Optics's Harsh Environmental Optics (HEO), which can handle automotive and industrial machine-vision applications, are precision lenses sealed inside water-resistant optical assemblies. The lenses are offered in four focal lengths with two coating options. *Edmund Optics, www.edmundoptics.com.*

Instrument catalog

Keithley's 2007 product catalog includes tips for choosing the most effective solution for an application, for increasing productivity and lowering test costs, and for avoiding common measurement errors. *Keithley Instruments, www.keithley.com/at/410.*

Faster video inspection

Inspect faster with Camera Link cameras and the PIXCI E4 PCI Express x4 bus frame grabber from Epix. Extensive image-processing software now supports 64-bit Windows or Linux. *Epix, epixinc.com.*

Digital cameras

The Leutron Vision's PicSight cameras offer a choice of 28 CCD and CMOS sensors from VGA to 5 Mpixels. You can choose from GigE, Camera Link, and USB2 interfaces or choose in-camera processing with a smart camera module. *Leutron Vision, www.picsight.com.*

Microwave connectors

The Gore 100 series connectors are high-density blindmate, high-performance microwave interconnects offering performance through 100 GHz. The connectors meet the industry's demand for increased packaging density, performance, and low mass. *W.L. Gore & Associates, www.gore.com.*

Test and debug solutions

Intellitech lowers test costs with patented approaches to prototype test, silicon debug, production PCB test, multi-PCB system test, environmental stress screening, and in-the-field test. *Intellitech, www.intellitech.com/tmwcp.*

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3. Sales through dealers and carriers, street vendors, counter sales and other paid or requested distribution outside USPS	1,228	1,175
4. Requested copies distributed by other mail classes through the USPS	None	None
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781-734-8423 Fax: 781-734-8070
Sales e-mail: tmwsales@reedbusiness.com
Editorial e-mail: tmw@reedbusiness.com
Web: www.tmworld.com

BUSINESS STAFF

Publisher: Russell E. Pratt
rpratt@reedbusiness.com
Marketing Manager: Laura Koulet
Assistant to the Publisher: Darlene Fisher

Market Research Director: Rhonda McGee

Group Production Director: Dorothy Buchholz
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CHRISTOPHER ZIOMEK
President and Founder
ZTEC Instruments
Albuquerque, NM

Christopher Ziomek founded ZTEC Instruments, which designs and manufactures modular instrumentation products, in 1996. He has more than 20 years of experience in the test-equipment industry, as an instrument designer, engineering manager, and entrepreneur. At ZTEC Instruments, Ziomek guides the company's strategic vision and technology roadmap. Prior to founding the company, he worked as a section leader at the Los Alamos National Laboratory and as a microwave engineer at the Stanford Linear Accelerator Center. He holds BS and MS degrees in electrical engineering and is a licensed Professional Engineer in the state of New Mexico.

Chief editor Rick Nelson spoke with Ziomek at Autotestcon and followed up with an e-mail interview.

Adding a benchtop look and feel to modular instruments

Q: Could you describe the history of ZTEC?

A: ZTEC Instruments is currently celebrating its 10-year anniversary. ZTEC was founded as a custom-design-engineering firm. Our early efforts led to the development of our first standard product, a VXI-based digitizer. Development of standard products became a priority and led to the point where we are today.

Q: Could you summarize ZTEC's hardware and software offerings?

A: ZTEC develops modular instrumentation products for PCI, PXI, and VXI. Our product focus is modular oscilloscopes with many resolution and sample-rate options available. In addition, we offer analog and digital arbitrary waveform and function generators as well as RF and timing instruments.

Q: You mentioned VXI, and the new ZT4610 4-Gsample/s digital storage oscilloscope comes in VXI, as well as PCI, CompactPCI, and PXI formats. Many vendors seem to be deemphasizing VXI. Why introduce a new VXI instrument now?

A: VXI suffers a perception problem. Most people do not realize that it is a viable and significant market. Most of the negativity surrounding VXI has been generated from competing interests, not from actual users. Because users require the benefits that VXI delivers, it continues to be the platform of choice for many customers.

In addition, providing VXI support is quite simple for us. Our design philosophy is to reuse technology as much as possible. By making reuse a priority, we are able to port our designs to many platforms with minimal effort.

Q: Your new scope includes an onboard analysis library powered by a 64-bit processor. Why not rely on an external PC for processing?

A: There are many reasons why onboard processing is preferred. For one, much of the high-speed processing simply cannot be done rapidly using a centralized PC. Examples include continuous averaging, envelope capture, and limit testing. In addition, we feel that a PC-centric model puts too much of a burden on our users. The need for development, validation, and maintenance of complex software is undesirable. Instead, our onboard processing model provides a benchtop-like interface that requires only a thin layer of software to control the instrument.

Finally, we feel that onboard measurements increase test throughput. Instead of downloading entire waveforms, the user can simply download a measurement or test result.

Q: In addition to sample rate, what specs are important to your customers, and in those respects, how does your company compare with the competition?

A: Sample rate is a basic and important starting point when considering oscilloscope options. Bandwidth is also an important specification for many applications. The new ZT4610 family achieves sample-rate and bandwidth specifications comparable to most mid-performance benchtop oscilloscopes.

Beyond the banner specifications, users have many concerns. Items such as ease of use, screen-update rates, and product service and support are often just as important as the banner specifications. Satisfying all these requirements is a very challenging and exciting task that requires a close relationship with our customers. T&MW

Christopher Ziomek comments on emerging instrument standards and elaborates on ZTEC's past and future in the online continuation of this interview: www.tmworld.com/2006_11.